DEPARTMENT OF NATURAL RESOURCES

After the Storm

Urban Flooding Forum: July 17, 2024

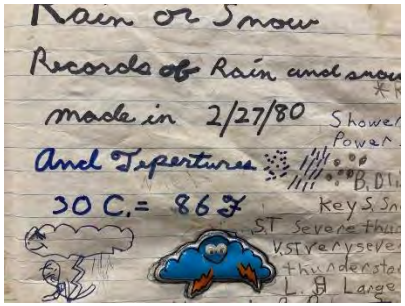
Flooding at KTTC: Rochester, MN July 6, 1978

-*Courtesy La Crosse NWS*

Pete Boulay, MNDNR State Climatology Office
Peter.Boulay@state.mn.us 651-539-2150

About Me

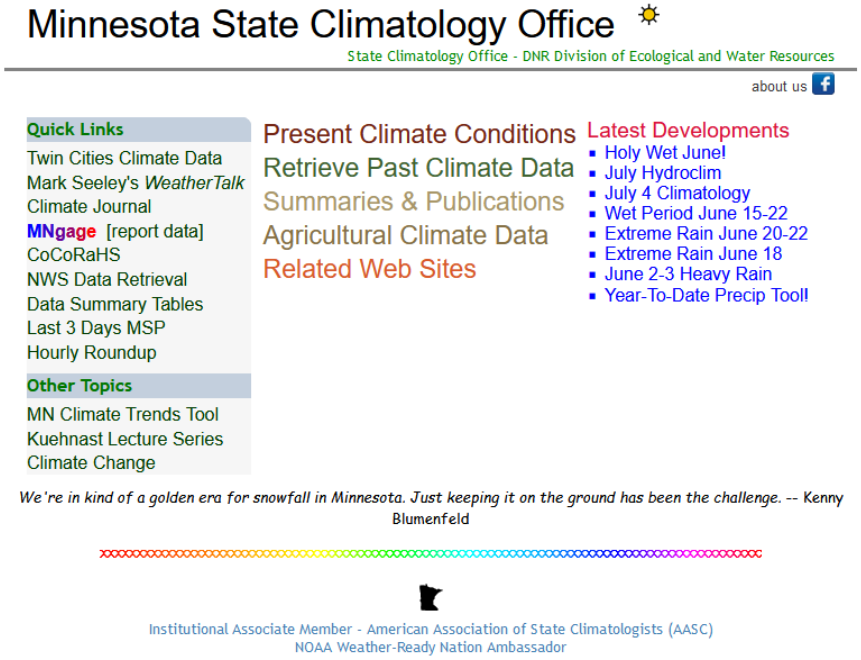
- Started watching weather at age 9
  - St. Cloud State University
  - Degrees in Meteorology and Broadcasting
- Weather Eye Inc. Kavouras, Inc.
- DNR State Climatology Office
  - 25 years
  - Lots of media interviews
  - Weather and History



DNR Climatology Website (since 1992)

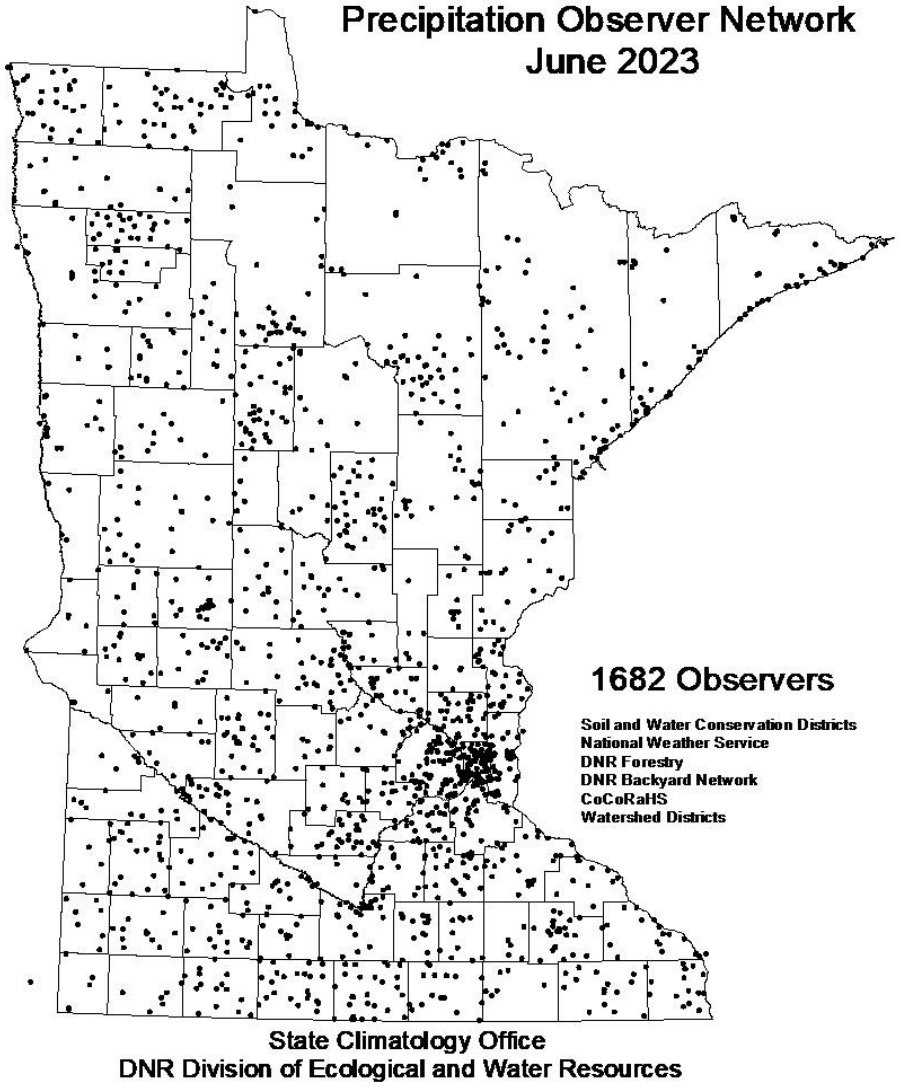
MN State Climatology Office

The DNR State Climatology Office manages, analyzes, and disseminates data and resources related to Minnesota's historical climate conditions to allow users to make informed decisions about future activities.



https://climateapps.dnr.state.mn.us

MNgage Volunteer Rain Gage Network

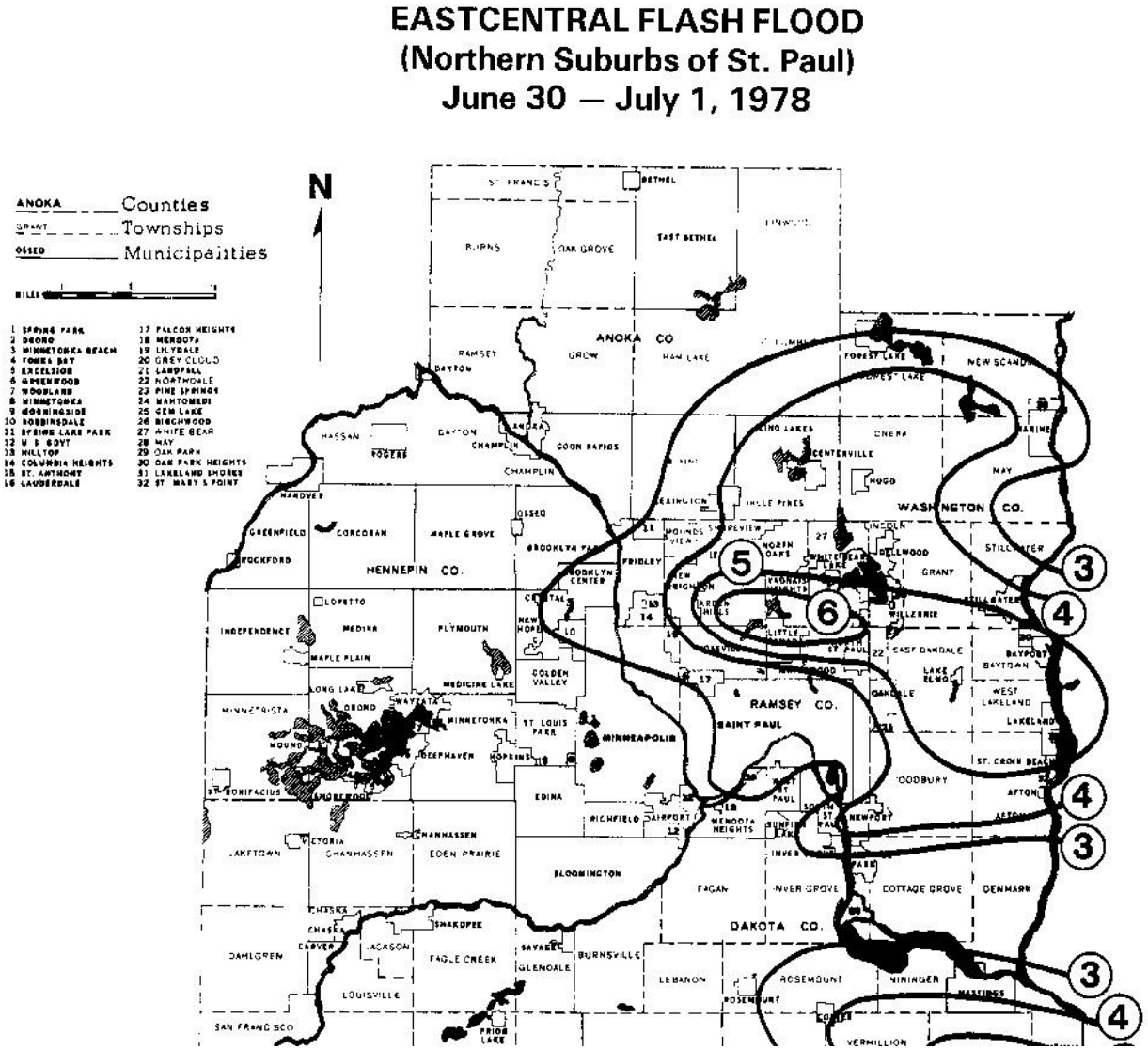


DEPARTMENT OF NATURAL RESOURCES

Equipment

Most observers use 4-inch plastic gauges

Storm of June 30-July 1, 1978



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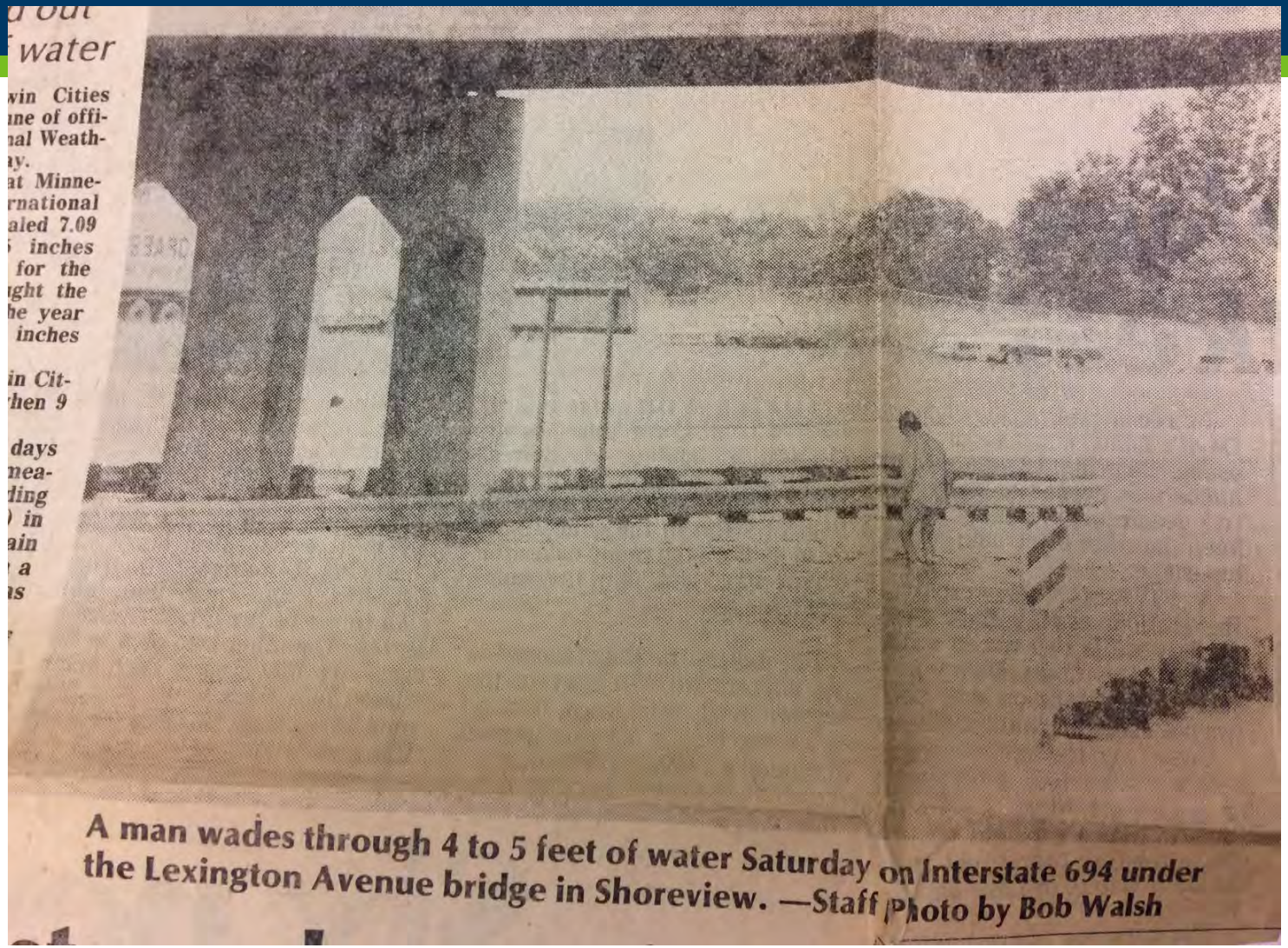

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A man wades through 4 to 5 feet of water Saturday on Interstate 694 under the Lexington Avenue bridge in Shoreview. —Staff Photo by Bob Walsh

Courtesy:
St. Paul Pioneer Press

Storm of June 30-July 1, 1978

County helping to fight flood

By GEORGE BERAN
Staff Writer

Ramsey County is helping homeowners battling high water and flooding near Gervais, Kohlman and Keller lakes.

With six inches of rain reported in the area Friday and Saturday, County Engineer Ken Weltzin said the Gervais-Keller-Phalen chain of lakes was the hardest-hit section of the county.

With the water in Lake Gervais about 18 inches above normal, the county built a dam over the weekend to restrict the flow from Willow Lake toward the Gervais chain.

The county has supplied 10,000 sandbags to homeowners protecting their property in low-lying areas near Gervais and Kohlman lakes, and has banned motor boats from eight lakes, fearing wakes would damage the threatened property.

Lake Gervais has overflowed its southern shore, flooding and closing County Road B2.

Weltzin said water in the chain has one place to empty: a sewer outlet at the southern end of Lake Phalen. Employees are stationed at Phalen on a 24-hour-a-day basis to keep the outlet open.

The county engineer said high water could be drawn out of the chain by Friday if no more rain complicates the situation.

Houses built during the last five years on low-lying areas near Lake Gervais appear to be bearing the brunt of the high water.

"We've been developing marginal land and it's hurting us now. We've taken away areas that used to hold water," Weltzin said.

One area lying west of Gervais that the county wanted to acquire for open space was vetoed a few years ago by the Little Canada local governing body.

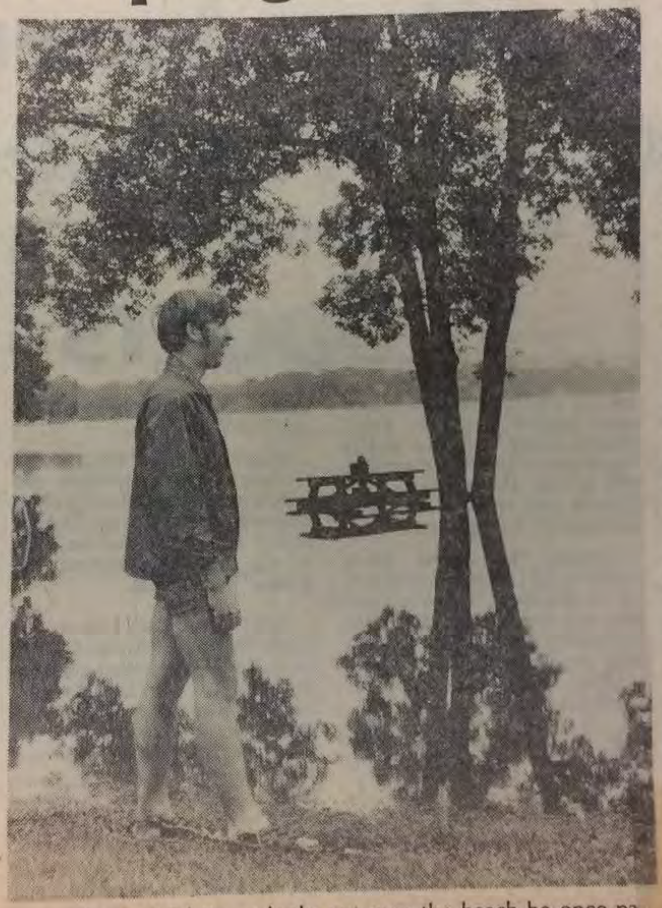
Weltzin said he has received cooperation from Little Canada recently on open space acquisition north of the lake.

The county has kept a 20-person crew working near the chain of lakes to patrol roads and assist in control efforts.

Mayor George Latimer's office said Monday that county residents may be able to qualify for low-cost, federal loans to repair houses damaged by flooding.

The loans will be made available under federal regulations the moment Hennepin County qualifies for the program.

Ramsey County lacks the required number of flood damage cases, but Minneapolis may have enough to qualify Hennepin. In that event, the Small Business Administration will allow Ramsey to qualify because it's adjacent to Hennepin.



Lifeguard Ed Byrne looks out over the beach he once patrolled at Lake Gervais in Little Canada. The beach was under water Monday. A picnic table gives evidence of the lake's new dimensions.—Staff Photo by Sully Doroshow

Courtesy:
St. Paul Pioneer Press

Storm of June 30-July 1, 1978

Tues., July 4, '78 11 CITY

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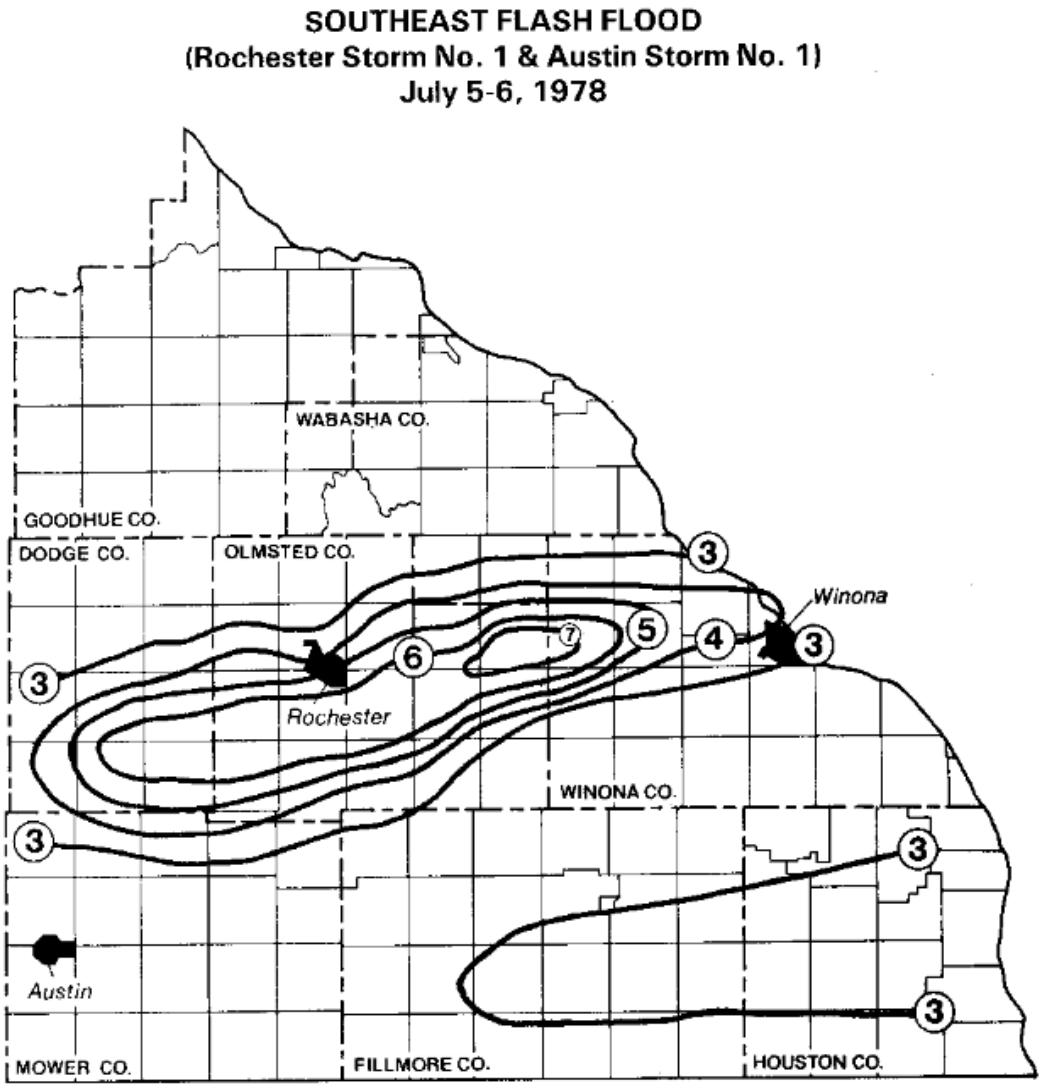
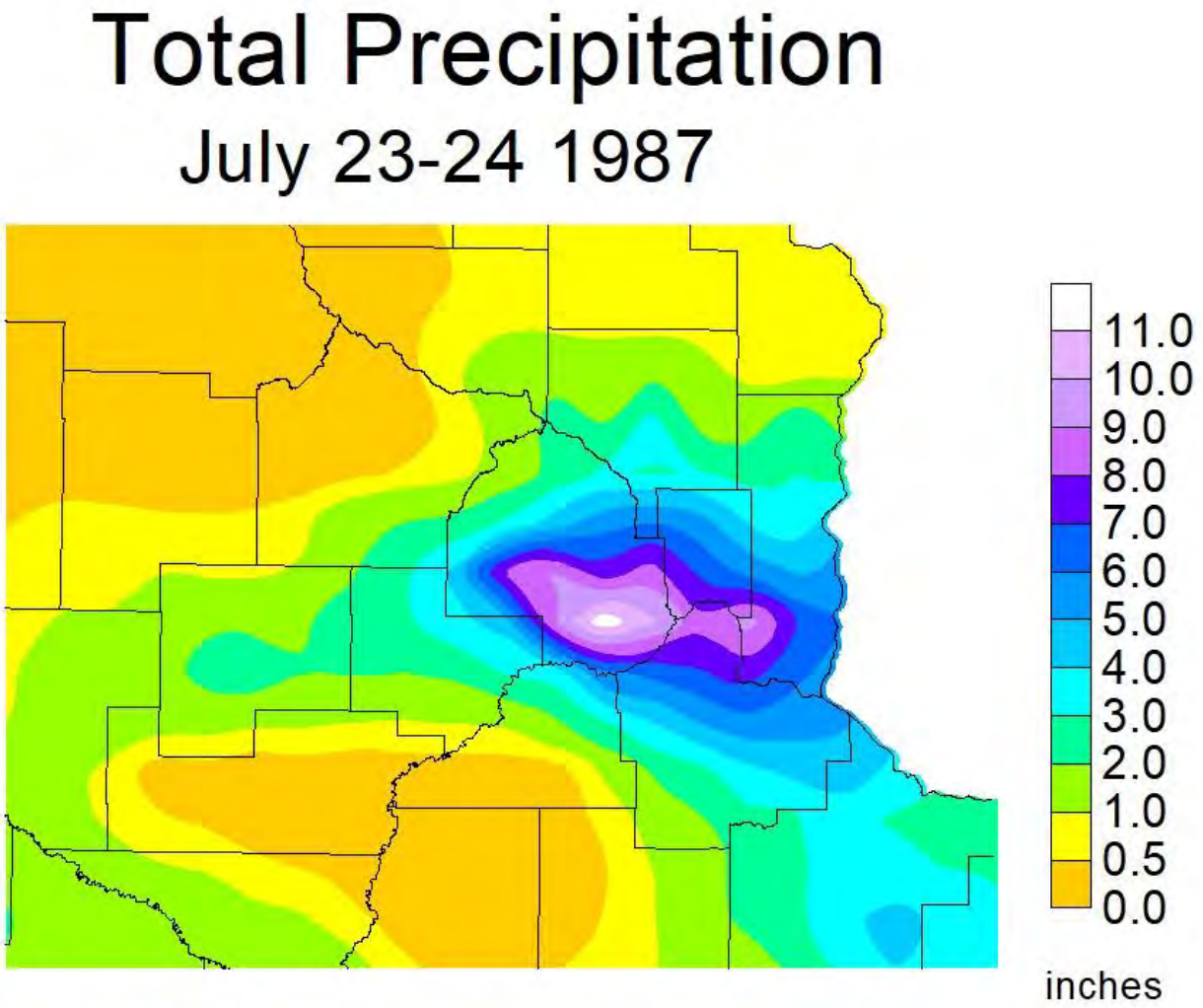
Courtesy:
St. Paul Pioneer Press

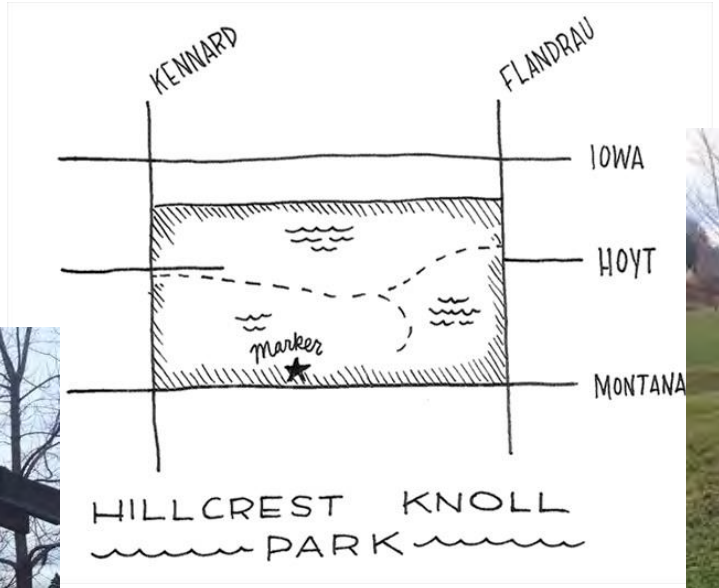
1978- Year of Floods!



The July 1987 Superstorm



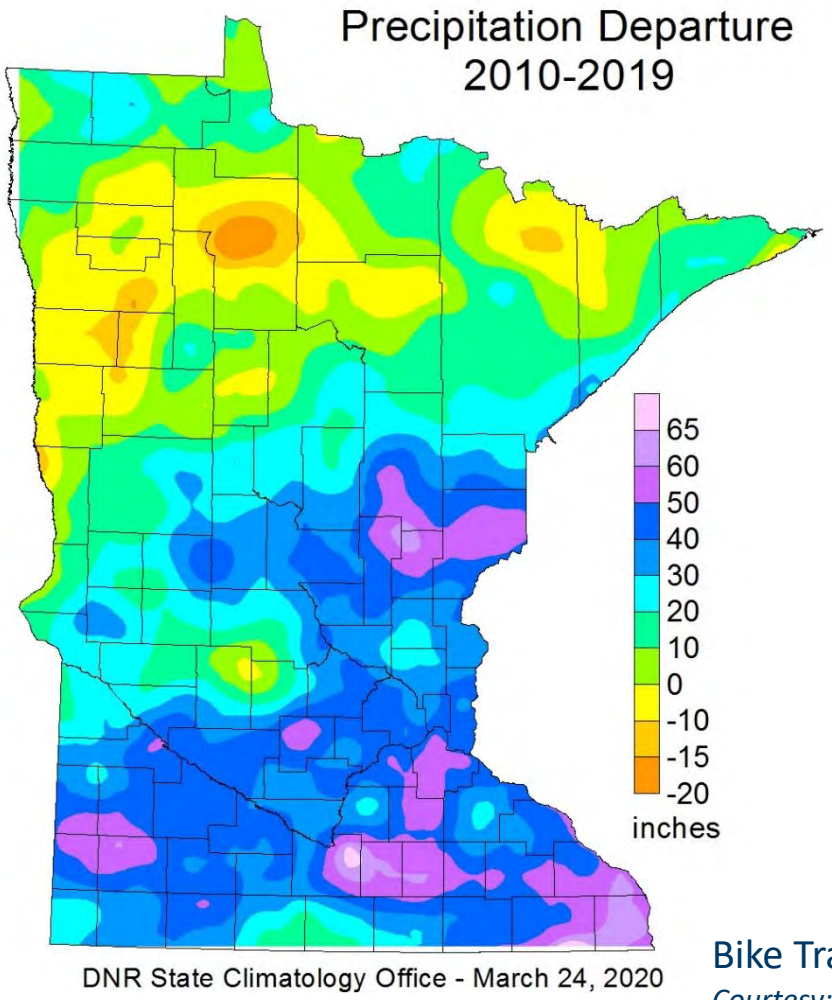
Storm of July 1, 1997



July 1, 1997. 2.41 inches fell in one hour at the Twin Cities International Airport. Total Rainfall 3-5 inches in this area.

Courtesy: Minnpost
https://www.minnpost.com/stroll/2016/12/hillcrest-knoll-park-reminder-neighborhood-lost-flooding/

Very Wet 2010s in Southern and Eastern Minnesota



During the decade, much of southern and eastern Minnesota accumulated 40-65 inches of surplus moisture.

Bike Trail in Maplewood

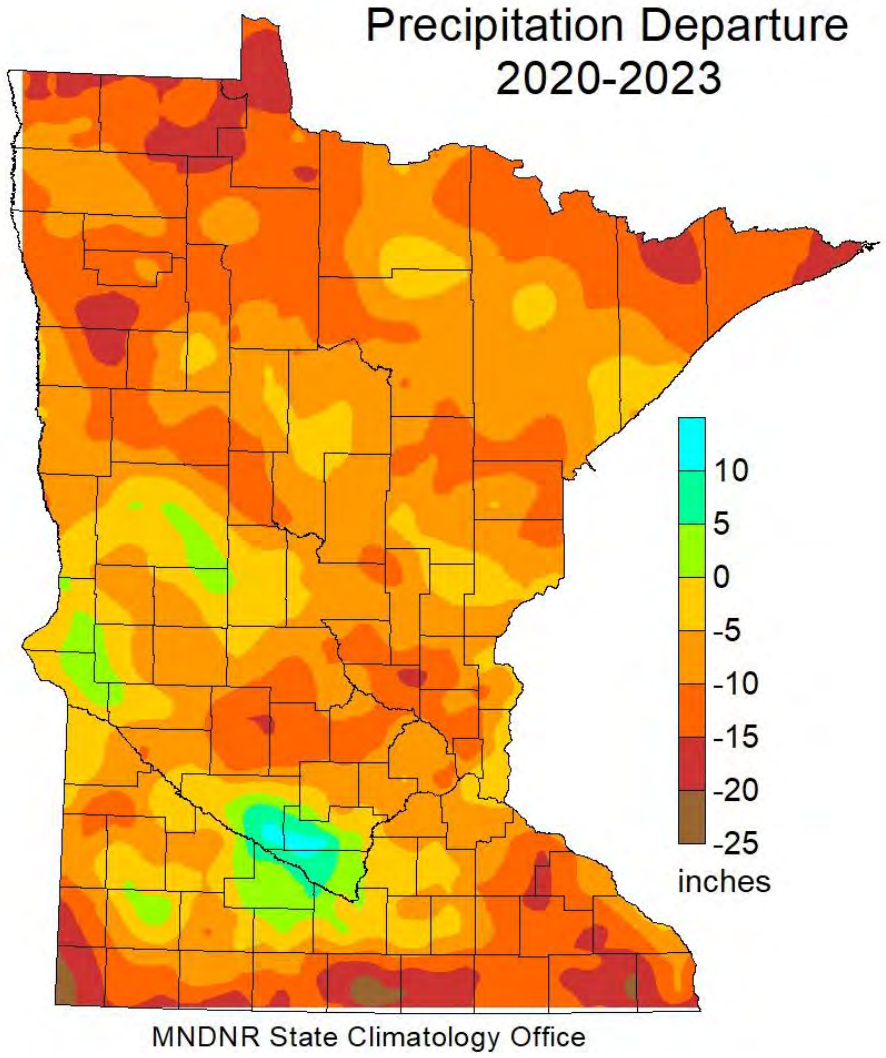
Courtesy: MNDNR State Climatology Office

Very Wet 2010s

Flooded Road under I-35 in Maplewood: June 2014

Courtesy: MNDNR State Climatology Office

Dry early 2020s in Minnesota

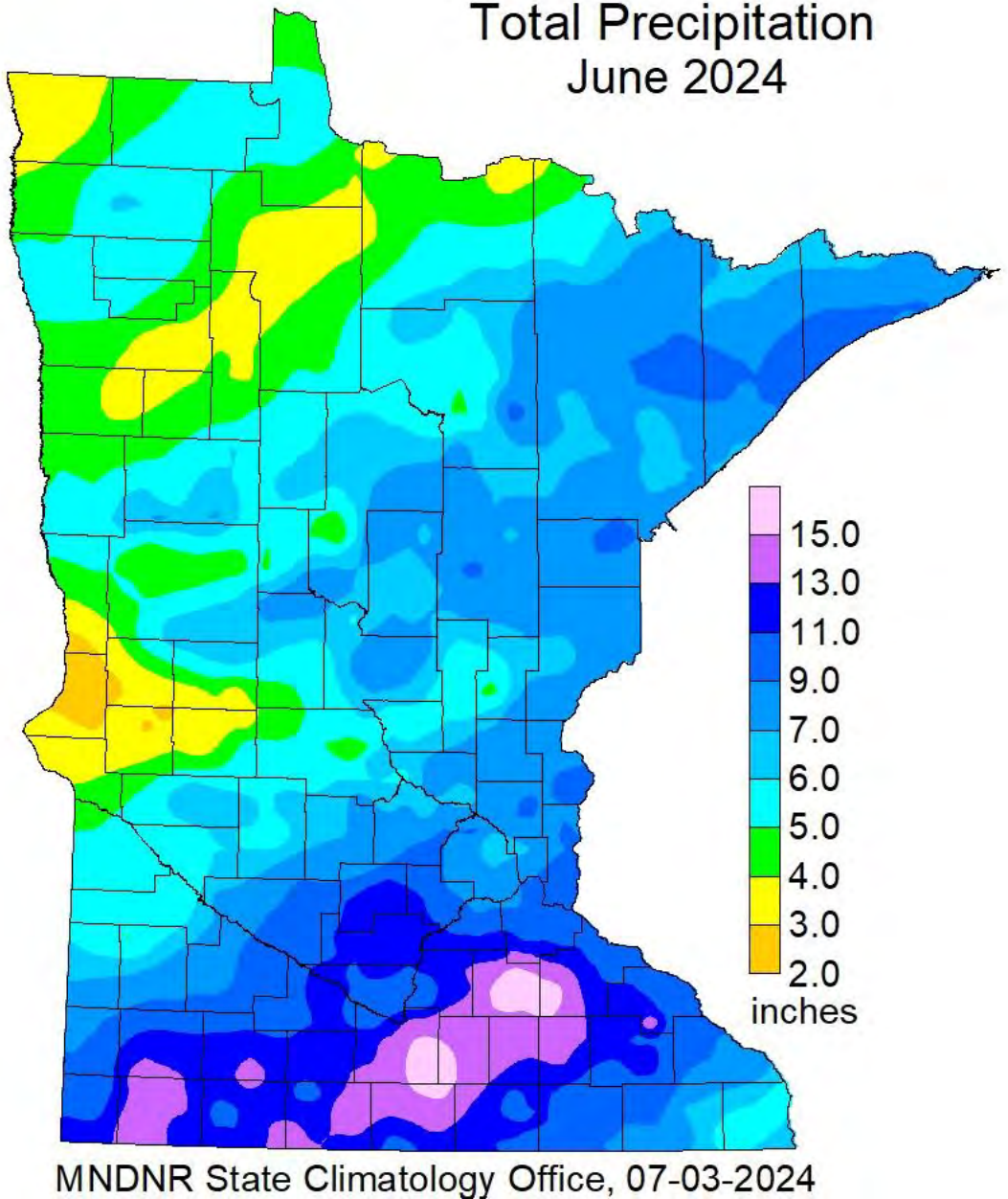


2020-23 precipitation deficits build with many places ten to fifteen inches short of normal.

Old oak barely hanging on. U of M St. Paul: October 5, 2022

Courtesy: MNDNR State Climatology Office

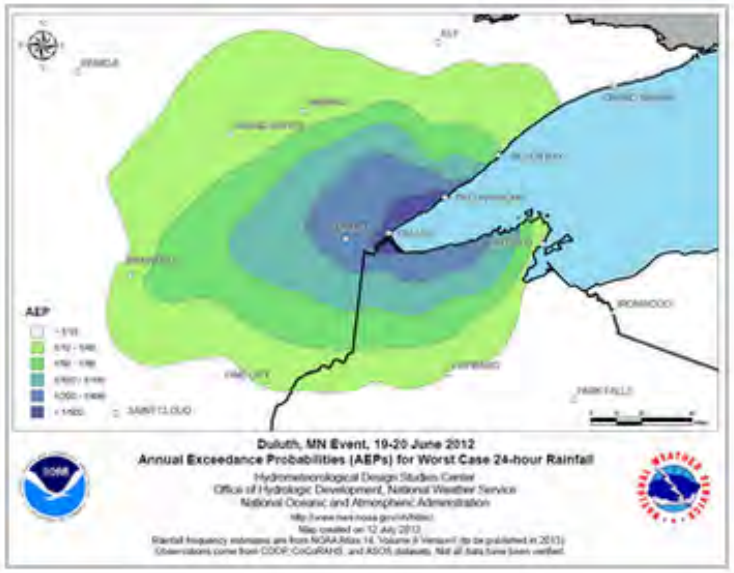
Droughts can be broken in spectacular fashion



NOAA Atlas 14 - precipitation frequency estimates

The National Weather Service Hydrometeorological Design Studies Center has released **NOAA Atlas 14, Volume 8**. The Atlas provides **precipitation frequency estimates** for many of the Midwestern states, including Minnesota. Analyses of the historical frequency of heavy rainfall events are of importance to engineers and others involved in designing and operating infrastructure such as culverts and stormwater runoff ponds.

NOAA Atlas 14 Precipitation Frequency Estimates for Minnesota



Click to enlarge

The information in NOAA Atlas 14, Volume 8 **supersedes** precipitation frequency estimates contained in these documents:

- Technical Paper No. 40 (1961)
- NWS HYDRO-35 (1977)
- Technical Paper No. 49 (1964)

The new estimates are based on improvements in three primary areas: denser data networks with a greater period of record, the application of regional frequency analysis using L-moments for selecting and parameterizing probability distributions, and new techniques for spatial interpolation and mapping. See the documentation (PDF) describing the station metadata, data, and project methodology used. Also, many questions are answered in the Frequently Asked Questions about NOAA Atlas 14 section of the National Weather Service Hydrometeorological Design Studies Center web site.

NOAA Atlas 14, Volume 8 was funded in part by the State of Minnesota, including funds provided from the Environment & Natural Resources Trust Fund.

The Future???

Website: https://www.weather.gov/owp/hdsc
Email: hdsc.questions@noaa.gov
Locations: Tuscaloosa, AL – Silver Spring, MD – Chanhassen, MN

OWP | OFFICE OF WATER PREDICTION

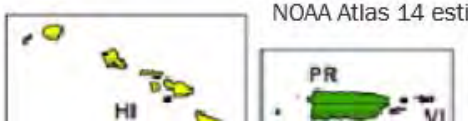
NOAA ATLAS 15:

Update to the National Precipitation Frequency Standard

NOAA is recognized by the engineering and floodplain management communities as the authoritative source of precipitation frequency data, and has a long history of generating these data that serve as the foundation for built infrastructure nationwide.

The National Weather Service (NWS) Office of Water Prediction (OWP) has produced an authoritative atlas of precipitation frequency estimates, published as volumes of the NOAA Atlas 14 Precipitation-Frequency Atlas of the United States. These estimates are currently posted on the NOAA Precipitation Frequency Data Server (PFDS), with interactive tables and charts. Precipitation frequency estimates are defined as the precipitation depth at a particular location, for a given storm duration, that has a statistically-expected 1-in-YY chance of being exceeded in any given year, where YY is the statistical annual recurrence interval.

States and territories associated with each NOAA Atlas 14 volume

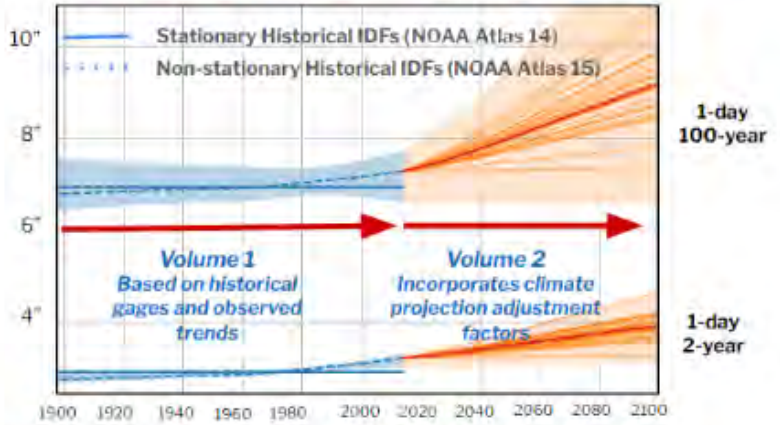


NOAA Atlas 14 estimates are used to design, plan, and manage much of the Nation's infrastructure for a wide variety of purposes

- Developing a seamless national analysis based on historical data and a non-stationarity assumption using the latest precipitation observations and future climate model projections. Storm durations will range from 5-minutes to 60-days and span average annual recurrence intervals of 1 to 1,000 years.
- Enhancing Web visualizations and data services, through NOAA's Service Delivery framework initiative, to better engage stakeholders and users.

NOAA Atlas 15

New National Precipitation Frequency Standard



Historical and future intensity-duration-frequency estimates (IDFs)

Timeline for the Development and Deployment of Updated Authoritative Precipitation Frequency Estimates Nationwide

2022/2023

- **Feb. - Aug 2022** - Published methodology and briefed stakeholders.
- **Sept. 2022** - Distributed Public Notification Statement (PNS) and collect public feedback.
- **Jan. 2023** - Hosted technical workshop with federal partners.

2024

- **Development** - Evolve framework. Create Quality Controlled National Precipitation Database. Evaluate Climate Model Projections.
- **Pilot** - Deliver Atlas 15 Vol. 1 and Vol. 2 pilot over Montana.

  Collect and adjudicate feedback on preliminary

2025

- **CONUS** - Distribute preliminary CONUS estimates for Atlas 15 Vol. 1 and Vol. 2 (lower 48 states).

  Initiate 60-day peer review for Atlas 15 Vol. 1 and Vol. 2.

  Collect feedback and adjudicate comments on product.

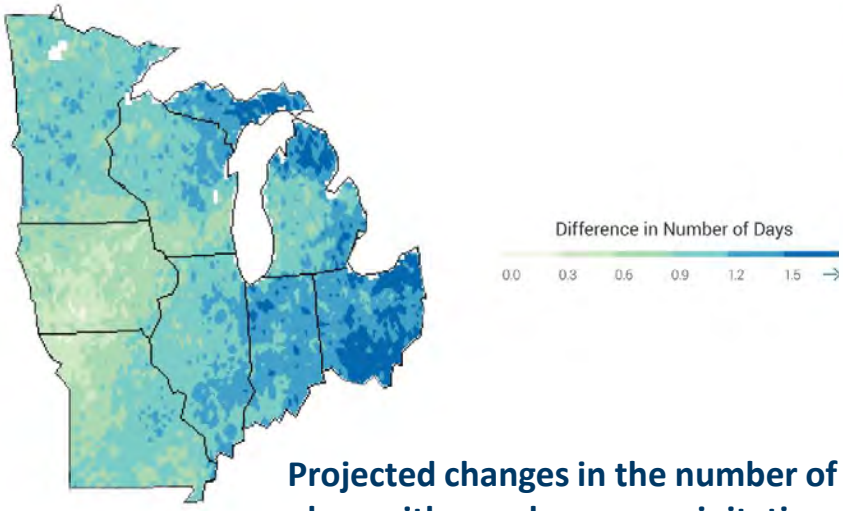
2026

- **CONUS** - Complete Atlas 15 Vol. 1 and Vol. 2 and deliver estimates, documentation and supplementary products to stakeholders.
- **oCONUS** - Initiate peer review for oCONUS (e.g. Hawaii, Alaska, Puerto Rico, U.S. Virgin Islands, Guam).

2027

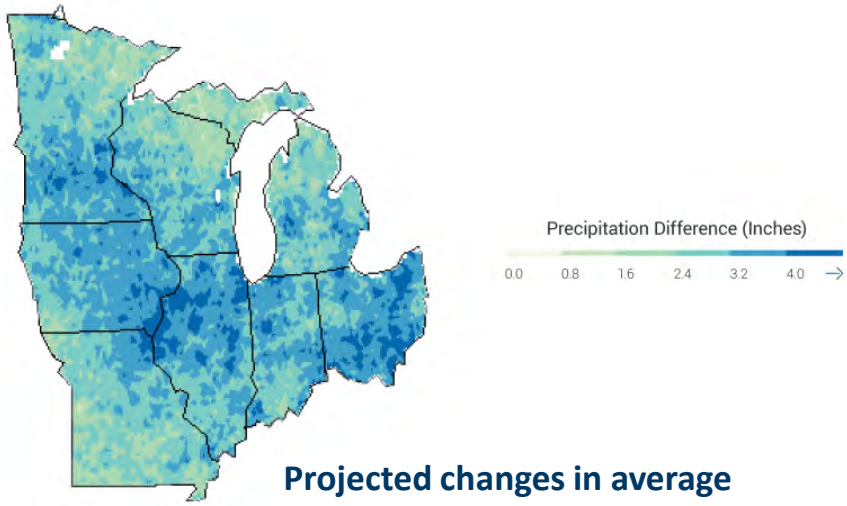
- **oCONUS** - Complete Atlas 15 Vol. 1 and Vol. 2 and deliver estimates, documentation and supplementary products to stakeholders.

What about 2041-2070?



Projected changes in the number of days with very heavy precipitation (top 2% of all rainfalls each year) for the middle of the current century (2041-2070) relative to the end of the last century (1971-2000) under continued emissions (A2 scenario).

Source: 2014 National Climate Assessment, Midwest Chapter



Projected changes in average annual precipitation for the middle of the current century (2041-2070) relative to the end of the last century (1971-2000) under continued emissions (A2 scenario).

Source: 2014 National Climate Assessment, Midwest Chapter

More precipitation and more heavy precipitation projected

In Summary

1. The 2010s were an extraordinary wet period.

2. Drought from 2020-2023, then a return to a wet regime?

3. Even though the trend is for a warmer and wetter climate, **expect variability**.

Flooded Street in Stillwater: July 2023
Courtesy: Fred Bowen, MNDNR

DEPARTMENT OF NATURAL RESOURCES

Any Questions?

Peter.Boulay@state.mn.us

651-539-2150

Departing Summer Storm: July 31, 2022

Courtesy: MNDNR State Climatology Office

Where are Flood Losses?

- For traditional spring flooding, most losses are in the FEMA mapped areas
- But overall, about 30-40% of National Flood Insurance Program (NFIP) claims are outside of the FEMA mapped areas
- Over 50% of overall damages from flooding (including those who don't have flood insurance) are outside of the FEMA mapped areas
- Trends are showing more of the overall damage outside of the FEMA mapped areas

Where are Flood Losses?

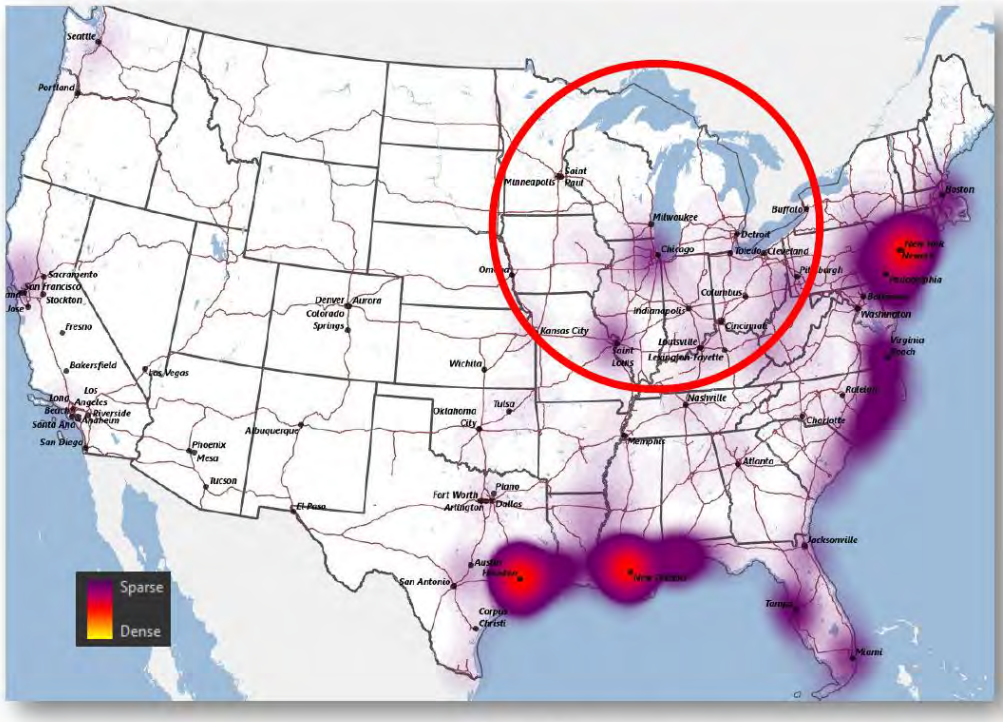
Some data from FEMA's Charlie Cook

Where are Flood Losses?

NFIP Repetitive Loss (RL)

Top 5 NFIP Loss Areas in Nation

State	Area	Structures
TX	Houston Harris County	21,481
LA	New Orleans Jefferson Parish	8,655
LA	New Orleans Orleans Parish	8,480
NY	New York Nassau County	7,089
NY	New York Suffolk County	3,926



FEMA

What are Repetitive Losses?

NFIP flood insurance claim data

- **Repetitive Loss (RL)**: Two or more $1,000 claim payments in a 10-year window
- **Severe Repetitive Loss (SRL)**: 4 or more $5,000 claim payments; or 2 or more paid losses cumulatively exceeding structure's value

Definitions vary between FEMA programs.

Losing Ground: Flood Data Visualization Tool (nrdc.org)

Where are Flood Losses?

**Includes a 21,762 increase after 2 federally declared disasters in 2023*

IA Repetitive Loss (RL)

Top 5 IA Flood Loss Areas in Nation

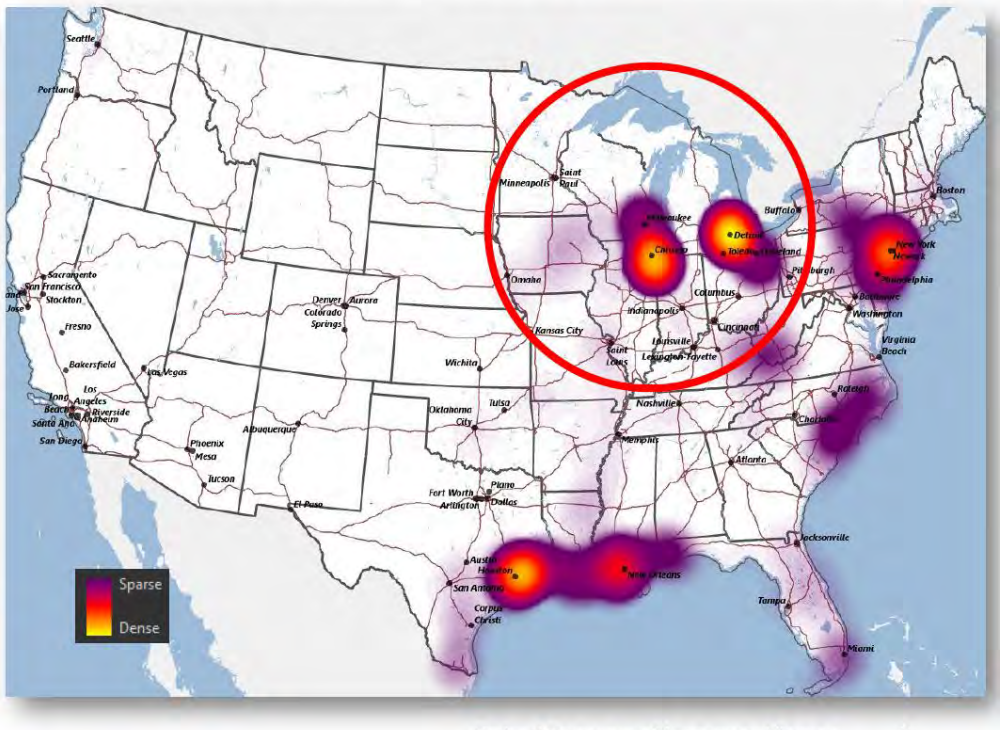
State	Area	Structures
IL	Chicago Cook County	*54,202
MI	Detroit Wayne County	41,114
TX	Houston Harris County	29,061
WI	Milwaukee Milwaukee County	8,185
OH	Cleveland Cuyahoga County	5,907

4 of the top 5

are in FEMA Region 5.

5th Highest Loss Area in Region 5

State	Area	Structures
IN	Gary Lake County	3,356



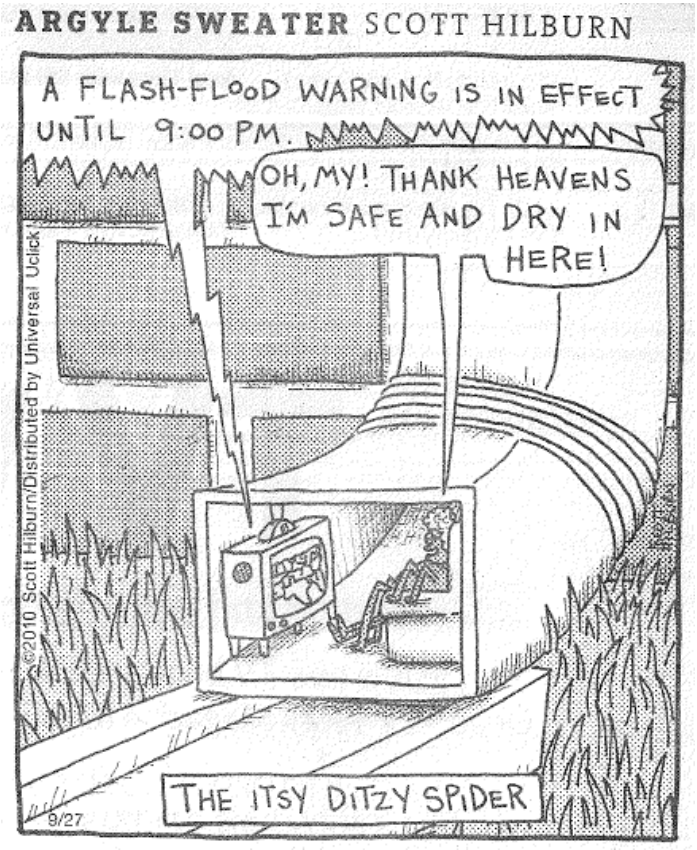
FEMA

Where are Flood Losses?

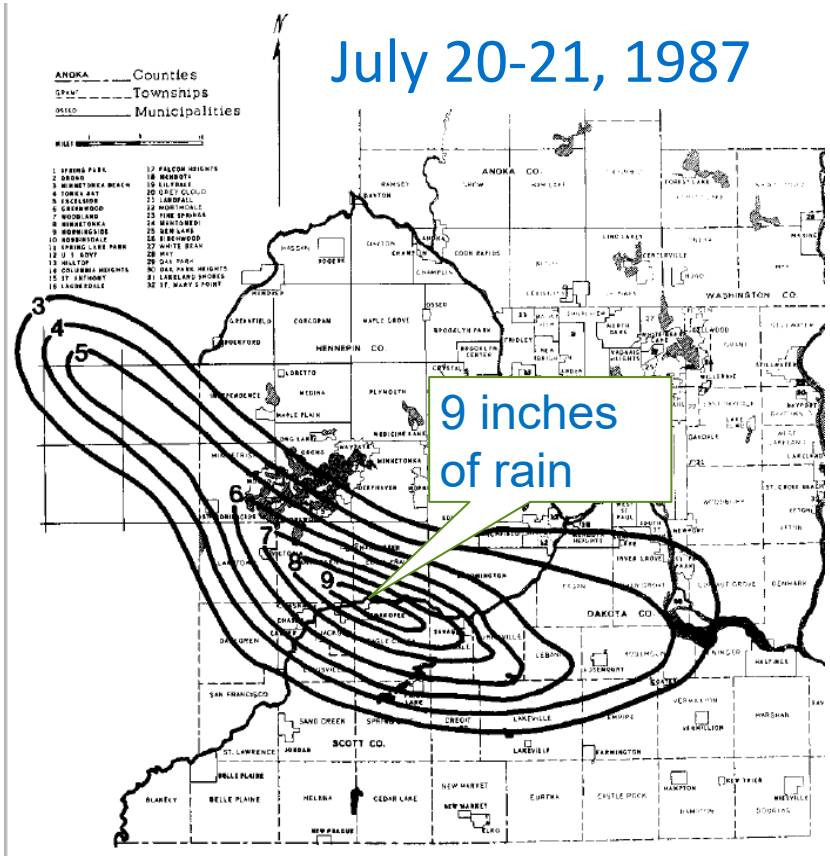
- Chicago area – 98% outside of the Special Flood Hazard Area (SFHA)
- Detroit, MI – 97% outside of the SFHA
- Cleveland, OH – 98% outside of the SFHA
- Gary, IN – 98% outside of the SFHA
- Milwaukee, WI – 99% outside of the SFHA

Local Flood Risk Reduction Efforts for Urban Flooding

First some history!



July 1987 “Superstorm”



Source: DNR State Climatology Office

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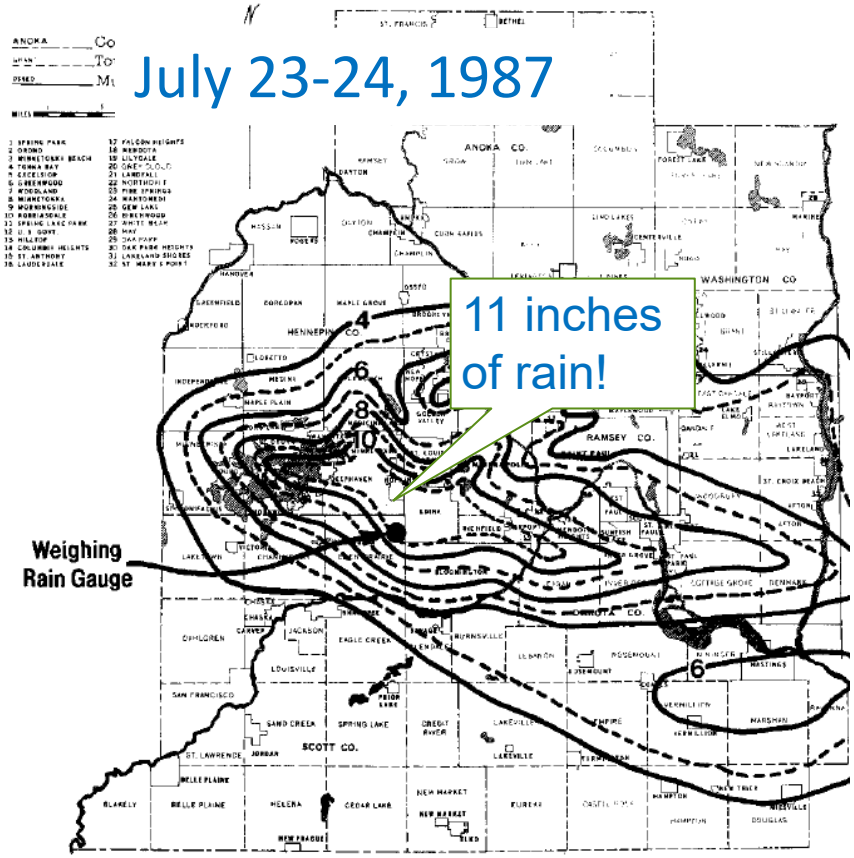
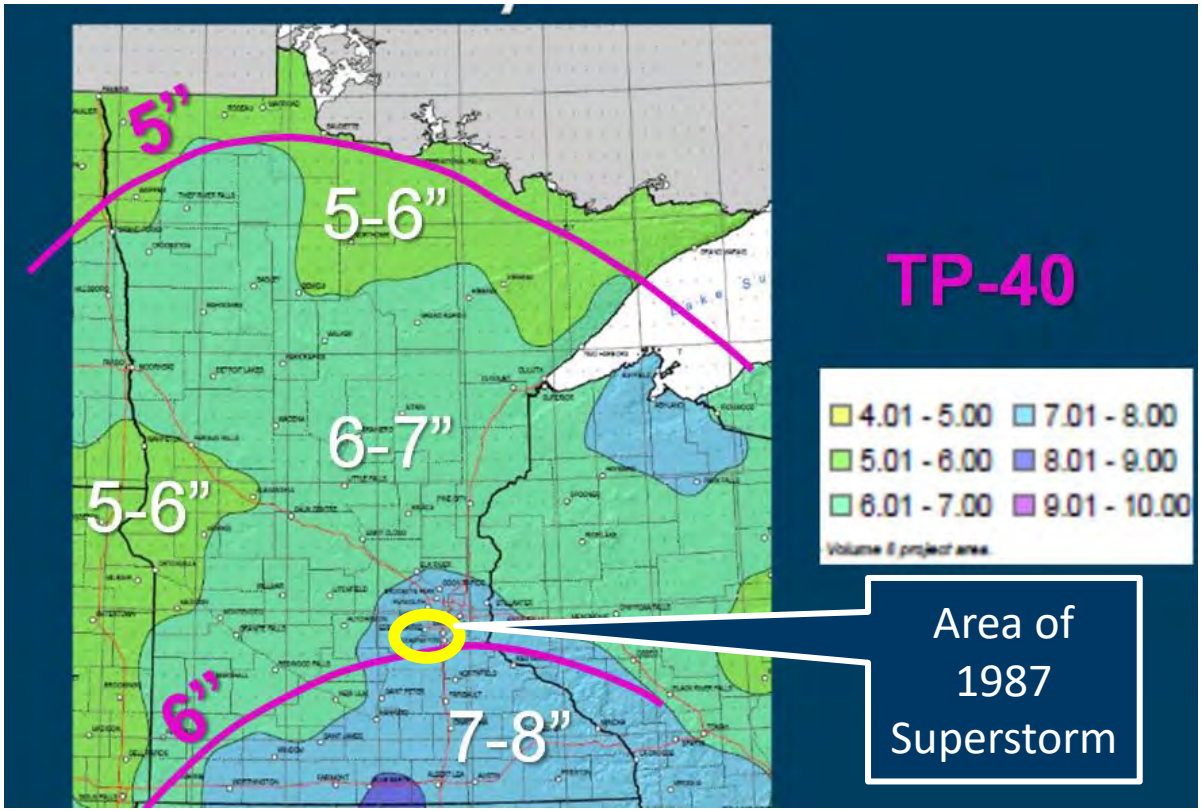


93 square miles with > 10 inches of rain!

Some areas saw > 16 inches with the 2 storms.

Source: DNR State Climatology Office

Comparison of Atlas 14 versus TP-40



July 1987 Flooding

Photo source: City of Bloomington

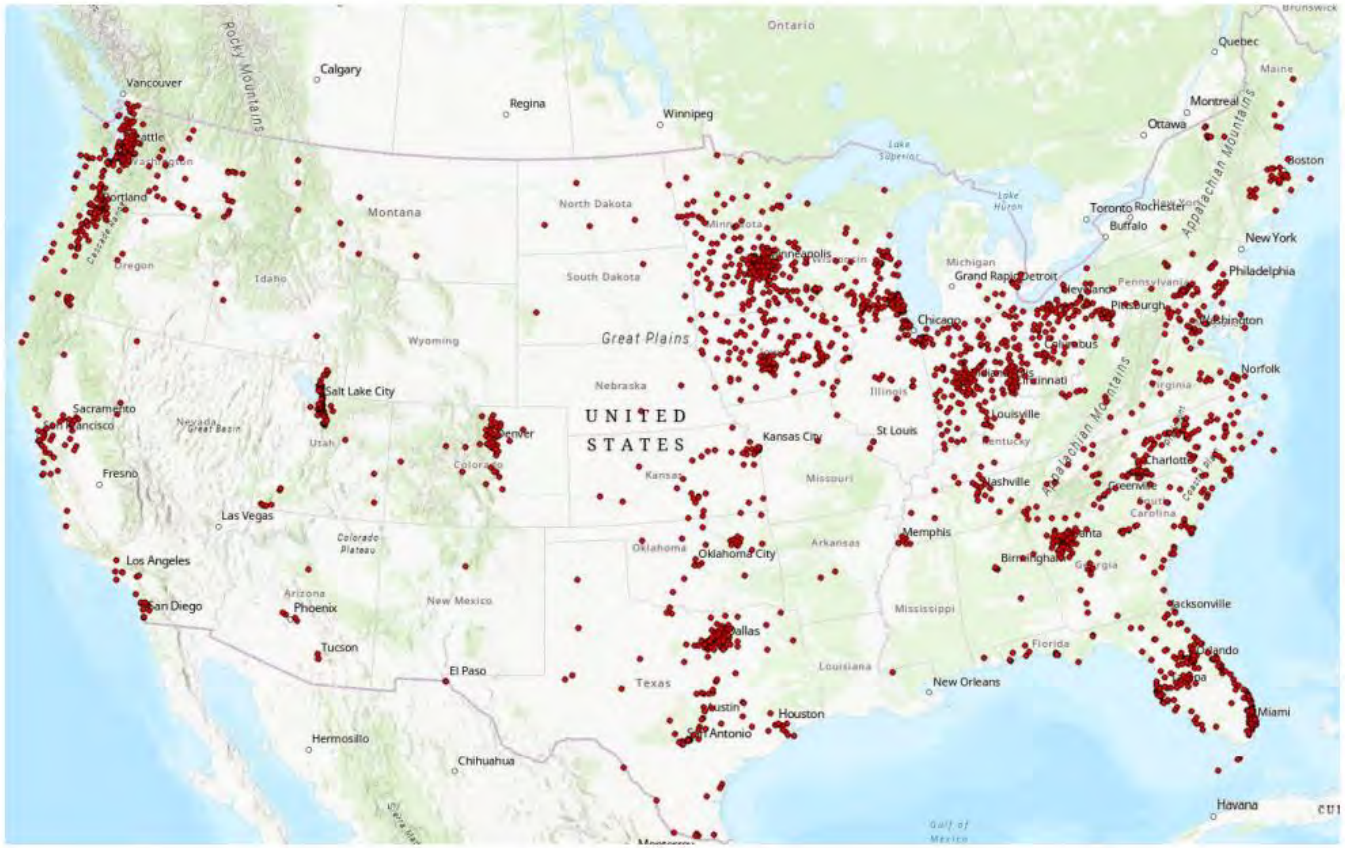
July 1987 Flooding on I-494

Photos source: City of Bloomington

Communities with Stormwater Utilities – Early Adoptors

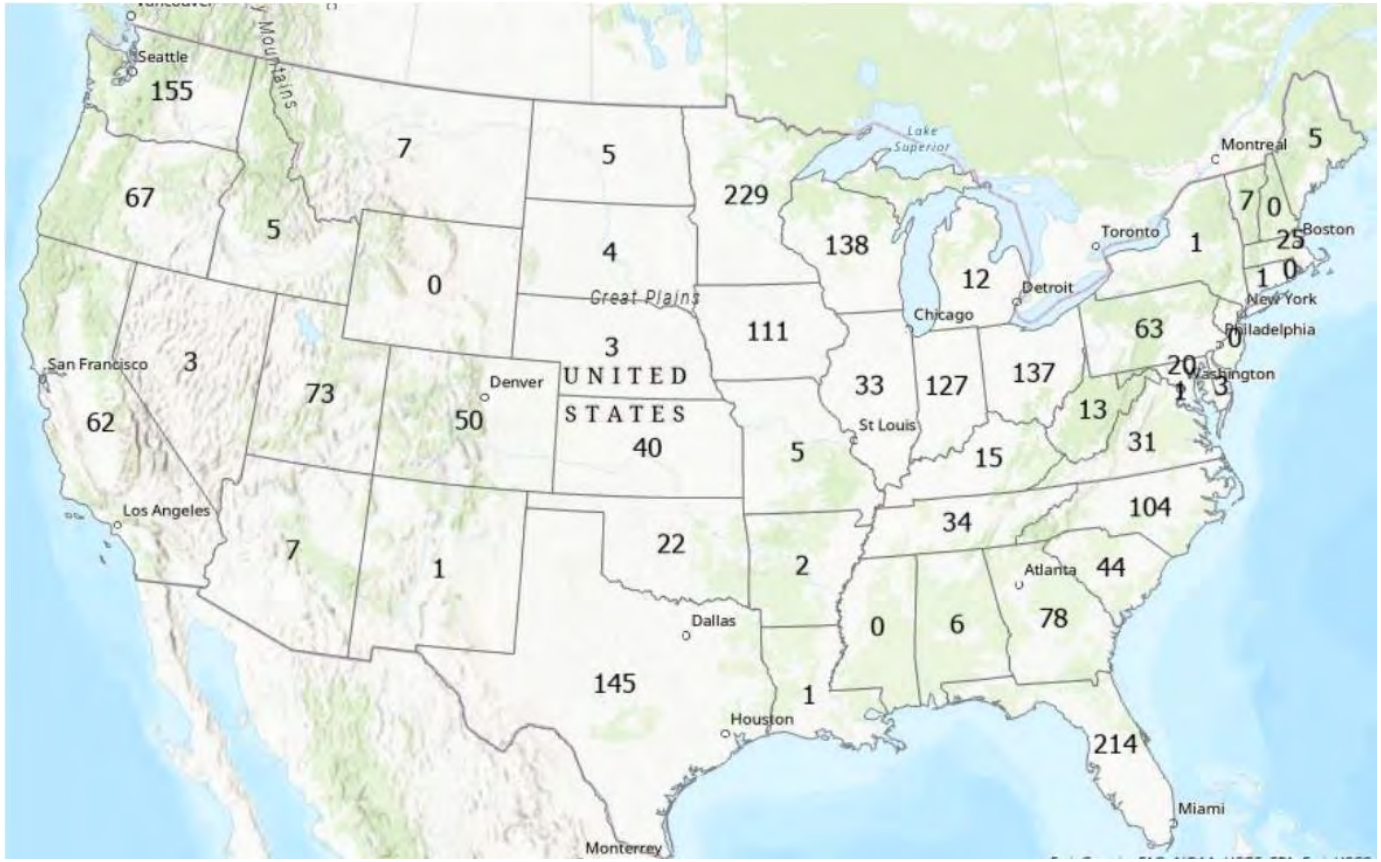
1984 Roseville
1985 Edina, Richfield, Robbinsdale, Shakopee
1986 Buffalo, Falcon Heights, Northfield, St Paul
1987 Fairmont
1988 Apple Valley, Bloomington (year after Superstorm)
1989 Hopkins

Communities with Stormwater Utilities



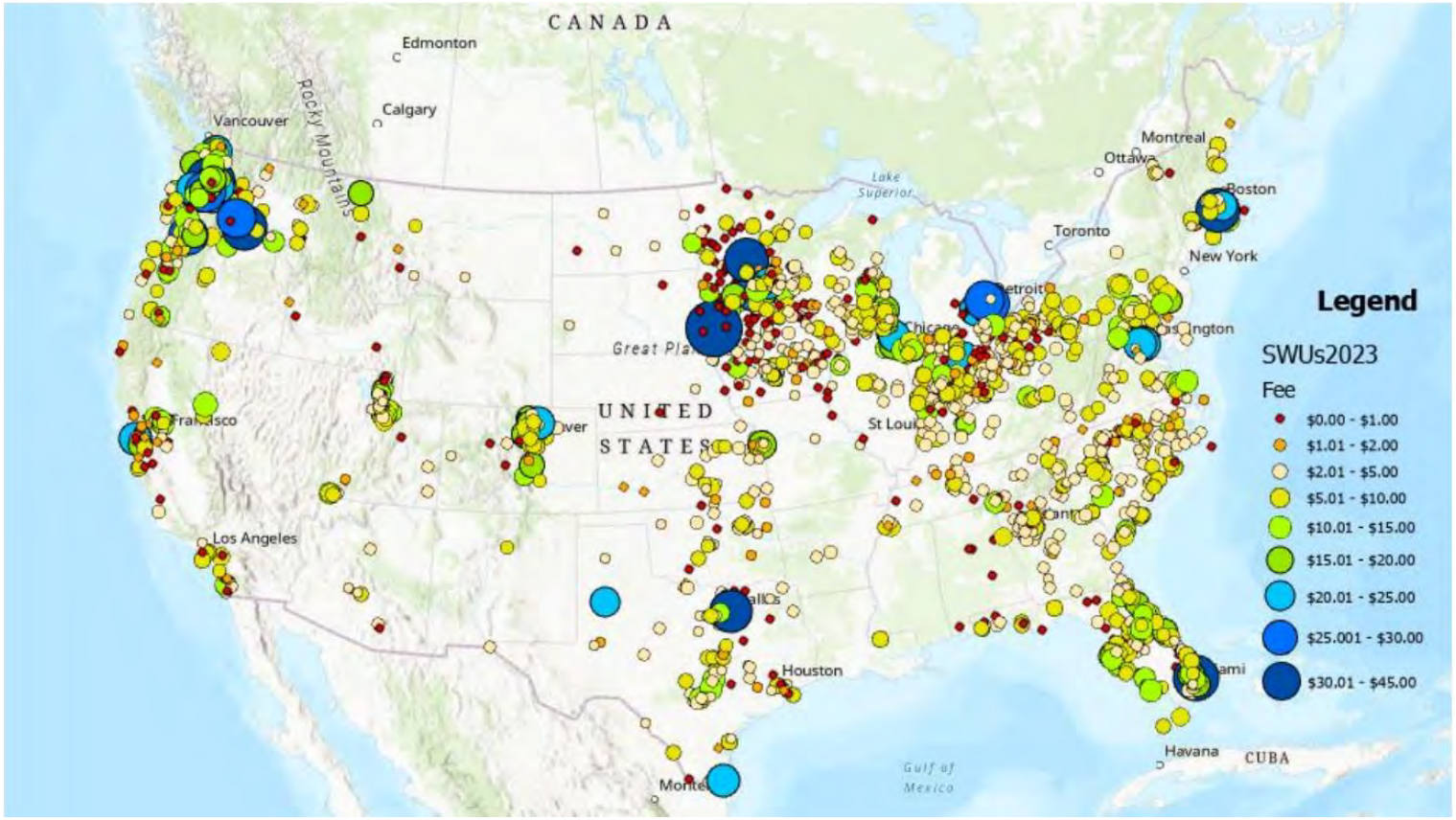
Source: [Western Kentucky University - 2023 Stormwater Utility Survey]

Stormwater Utilities by State



Source: WKU 2023 survey

Spatial Distribution of Monthly Stormwater Fees



Source: WKU 2023 survey

The CITY of EDINA

Reducing urban flooding impacts using smart infrastructure

July 17, 2024 DNR LGU forum

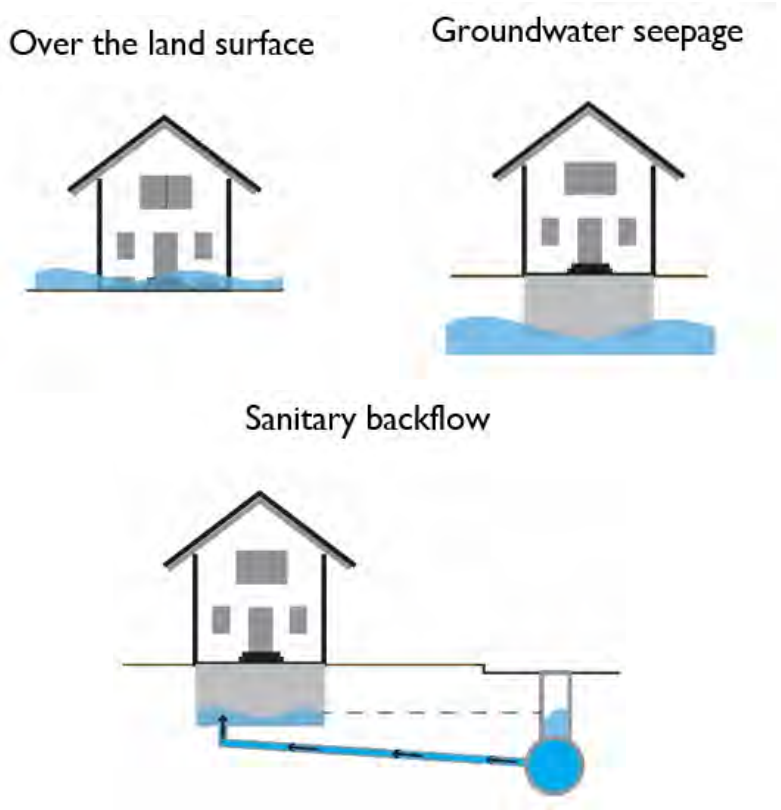
Ross Bintner P.E., Engineering Services Manager

Outline

- Flood context in Edina
- Flood Infrastructure / Recent project example
  - How it works
  - Importance of storage
  - Smart Infrastructure element
- Next steps

The CITY of EDINA

Risk Management



- Flood Risk Reduction Strategy approved by City Council in April 2020
- Incorporated into Water Resources Management Plan in 2022

Flood Risk Reduction Strategy

Comprehensively reduce risk throughout the community.

INFRASTRUCTURE

Building, renewing, operating, and maintaining assets that determine exposure to flooding.

REGULATION

Reducing exposure of homes and buildings, reducing vulnerability of homes and buildings that are exposed, ensuring people manage their own risk when making improvements, and taking actions that do not increase exposure of neighbors.

EMERGENCY SERVICES

Preparing for emergencies, helping the community recover after a flood, mitigating carbon emissions, and planning for more rain in the future.

OUTREACH & ENGAGEMENT

Promoting awareness of exposure and vulnerability, increasing system understanding, providing resources to help people reduce their own vulnerability.

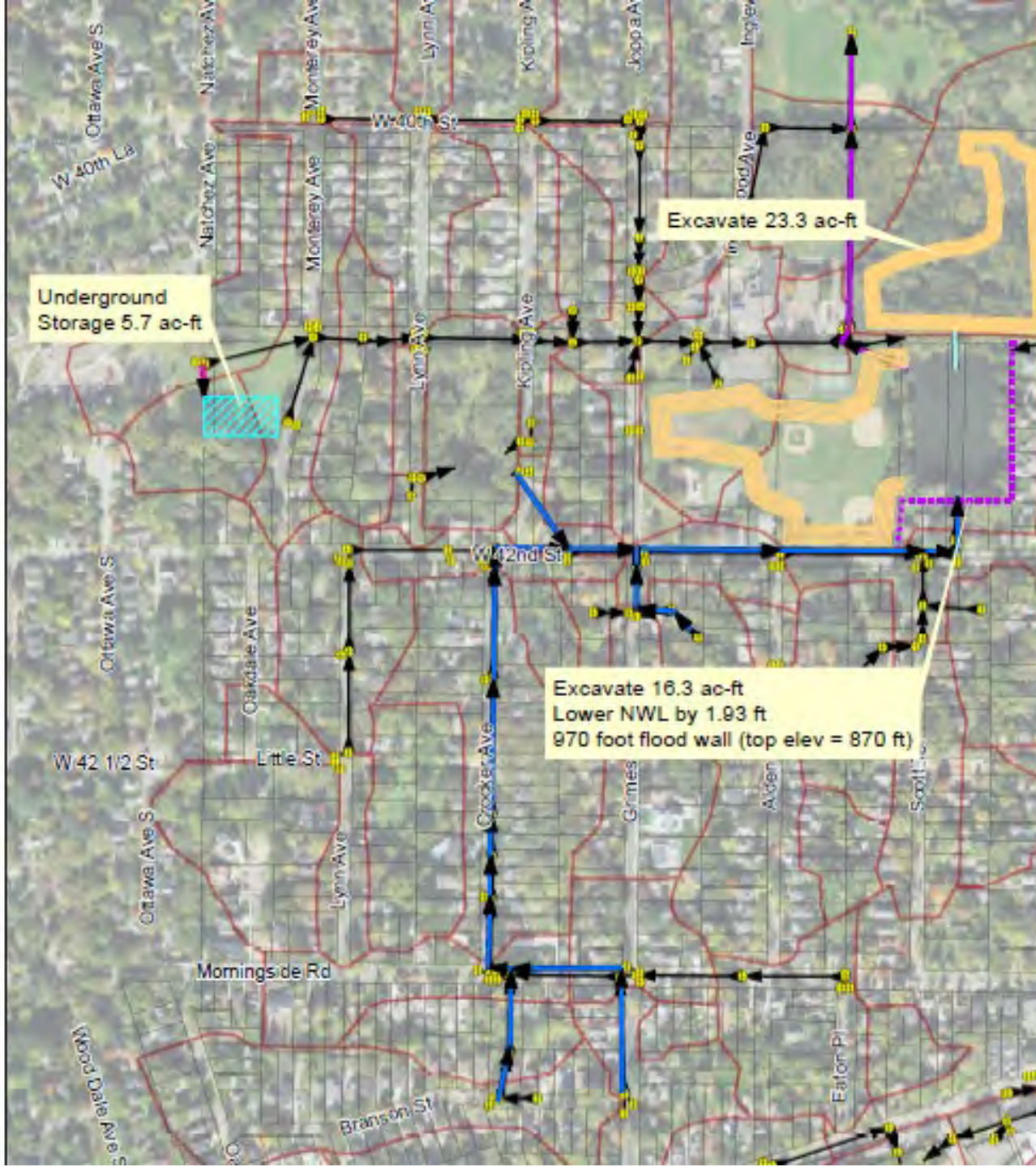
Magnitude of Flood Problem

- The 1% ACE Flood Map is shown to the right.
  - Urban first ring context
- On the surface, there is 130 acre-feet of water to be managed.
- There are nearly 150 homes that are at risk, either directly through entries or indirectly through elevated groundwater or sanitary backups.
- Some homes are very low

The CITY of EDINA

Feasibility stage

- Used the water model to assess many different options, considering conveyance, storage, and separation.
- What did we learn?
  - -This is going to be expensive
  - -Not everyone will be completely protected
  - -There will have to be trade-offs and balancing between costs and benefits
- Flood risk will be reduced; no one's flood risk will increase



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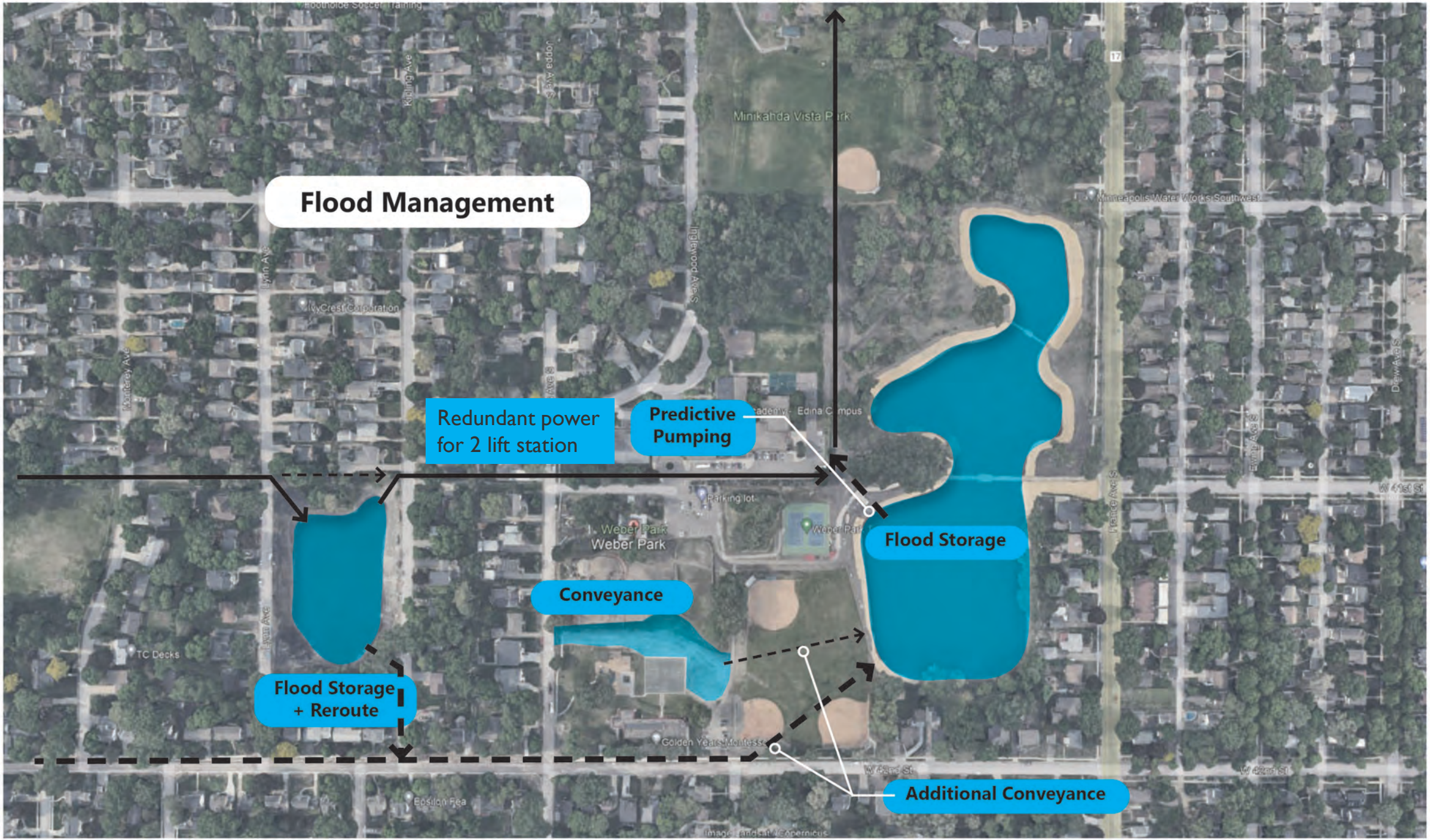
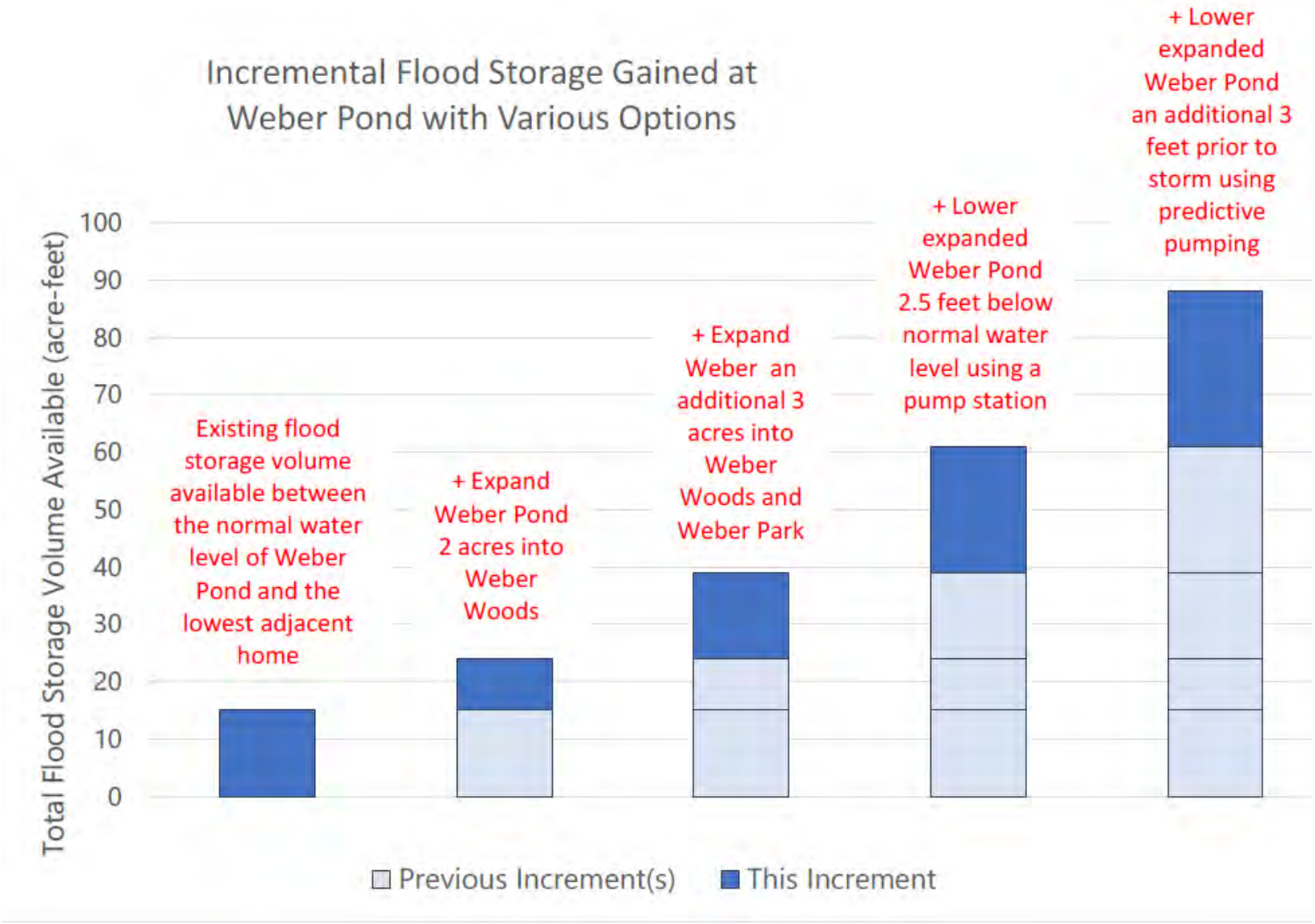

Flood Management
Redundant power for 2 lift station
Predictive Pumping
Flood Storage
Conveyance
Flood Storage + Reroute
Additional Conveyance
Minikahda Vista Park
Weber Park
Parking lot
TC Decks
Epsilon Tea
Minneapolis Water Works Southwest
Image Landsat / Copernicus

Critical pieces of the project

- Space is limited…how do you create the volume desired?
- Expanding a pond horizontally provides some volume
- Modifying vertically provides even more; $1M pump station
- $0.125M predictive pumping



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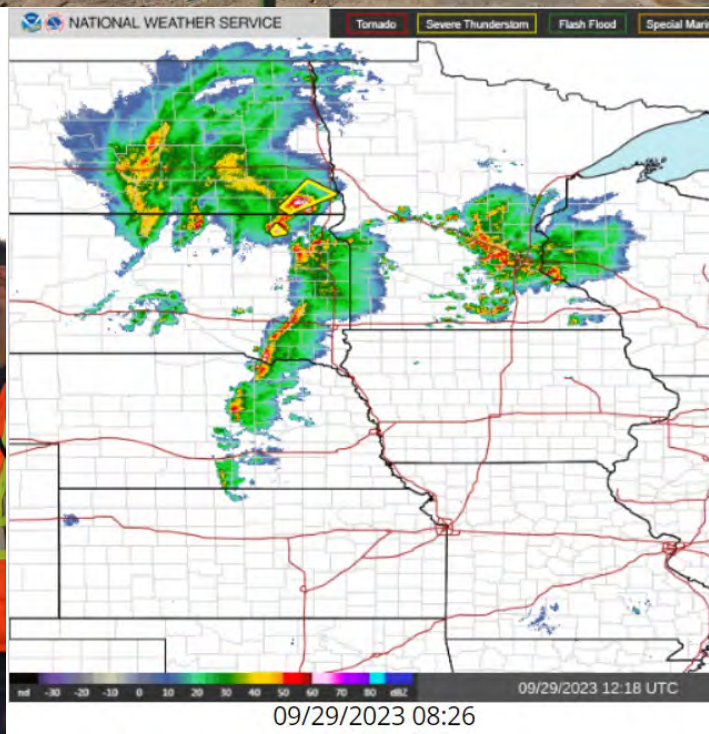
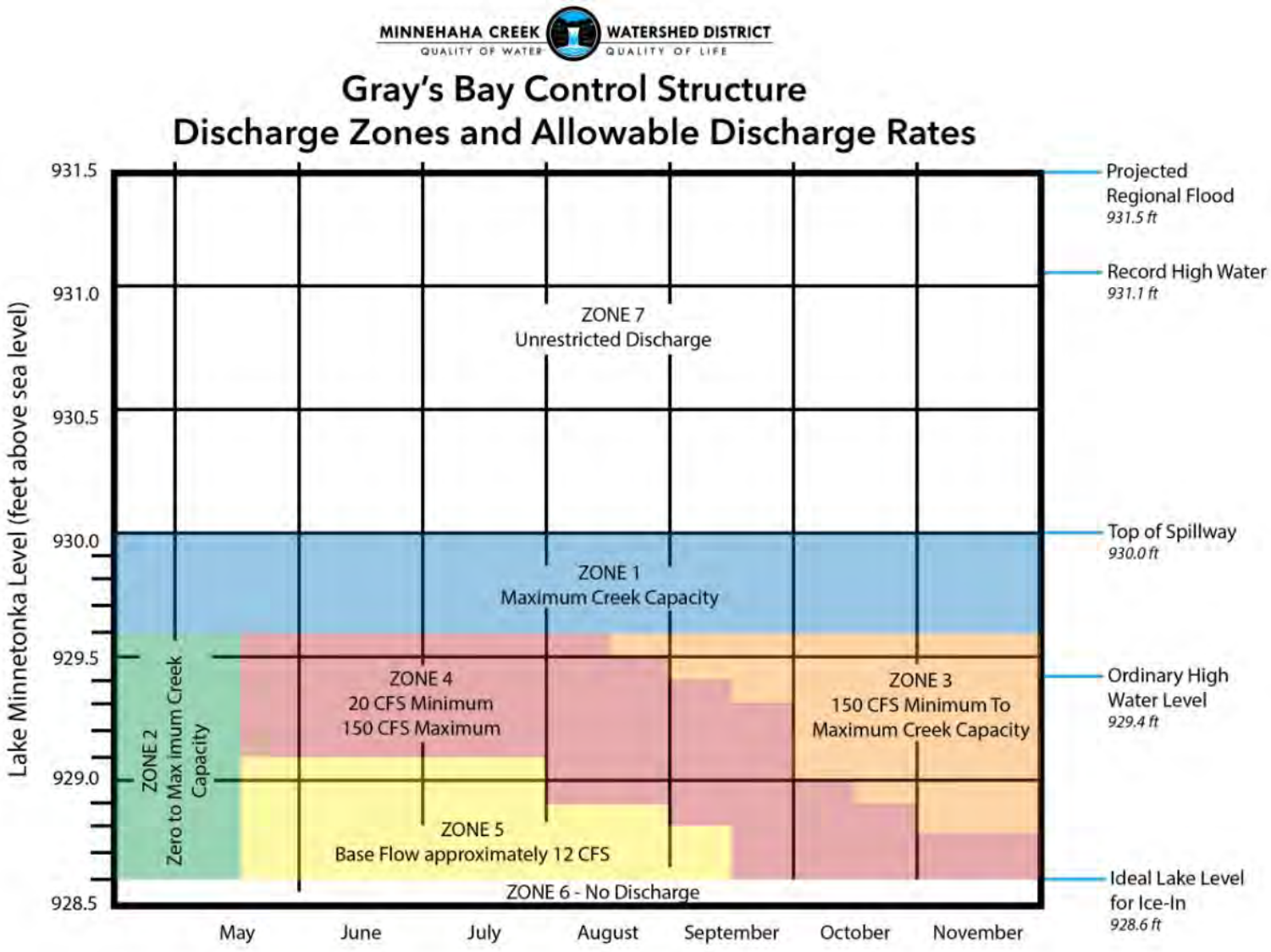


09/29/2023 08:26

What is Smart Infrastructure?

- May also be called adaptive level control systems or real time control.
- Established example is Gray's Bay Dam Operational Plan



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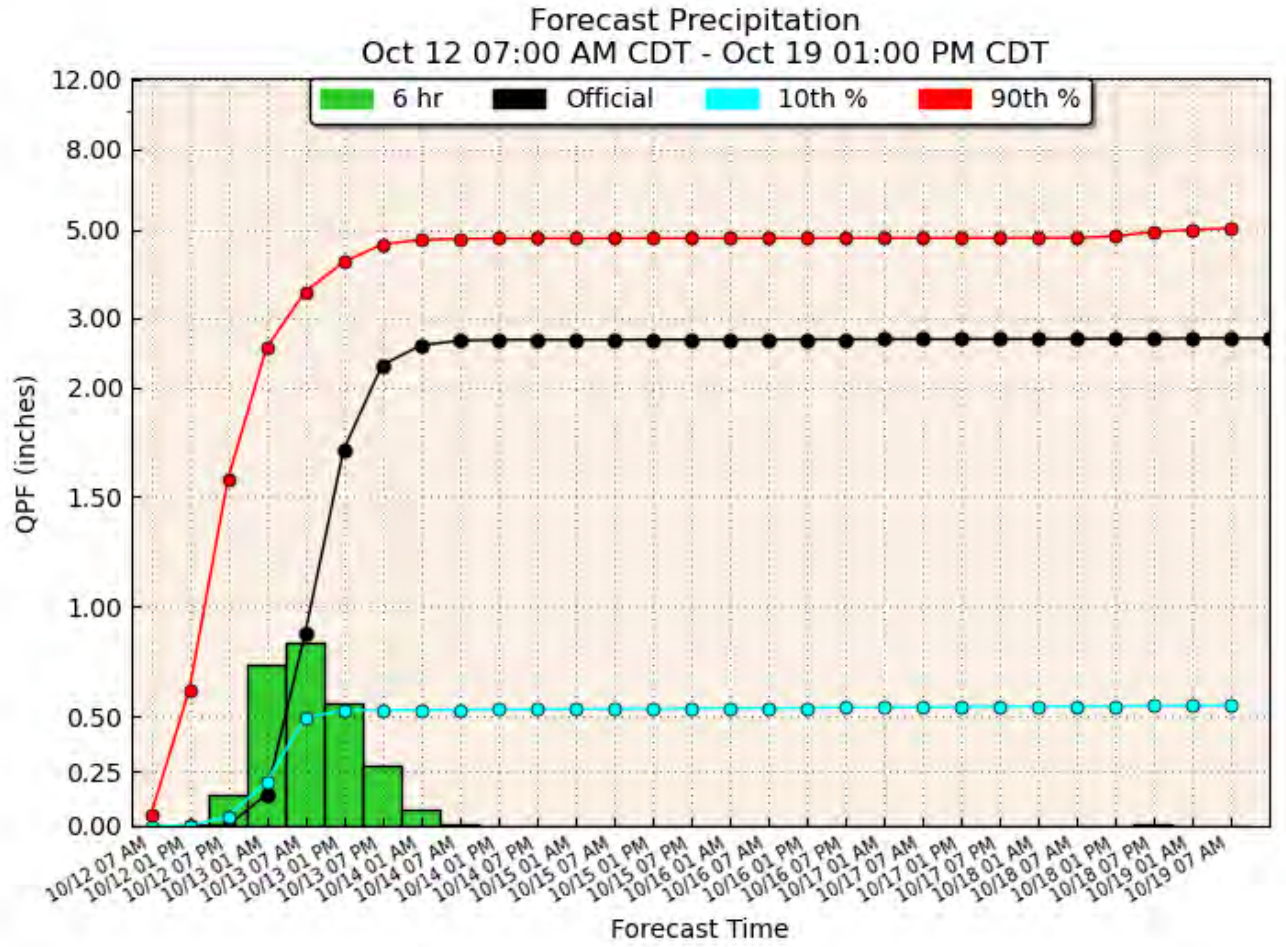
How it works: Data in

National Weather Service

- 6 hour forecast of probability & rainfall, 15-minute updates,
- Pressure transducer / Pond level

Landscape and drainage

- 368 acres watershed
- 40 ac-ft smart storage
- Stage-storage-flow
- Rainfall-runoff



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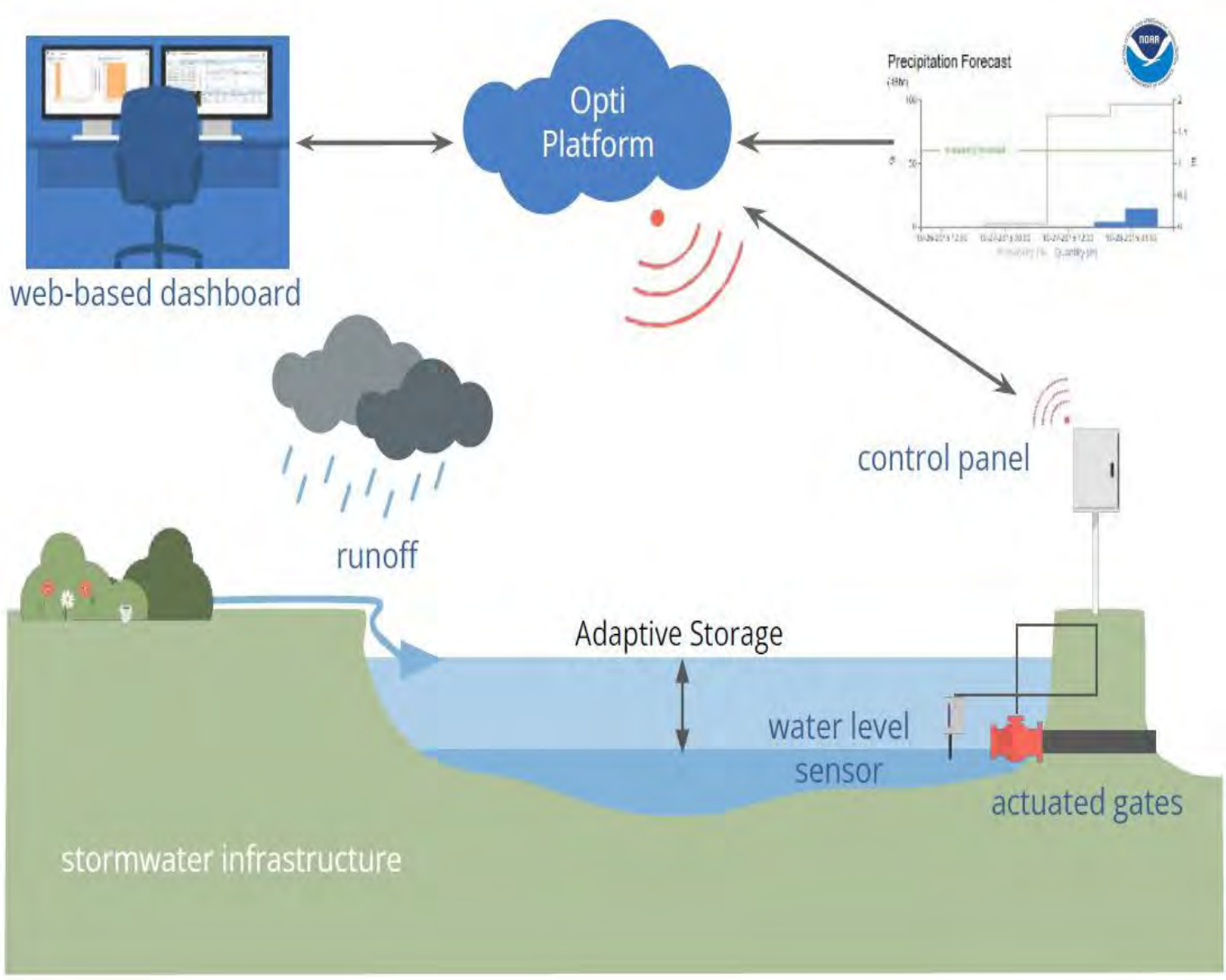
How it works: Plumbing

Typical components

articulated value shown

Morningside is a pump installation

Cloud Software

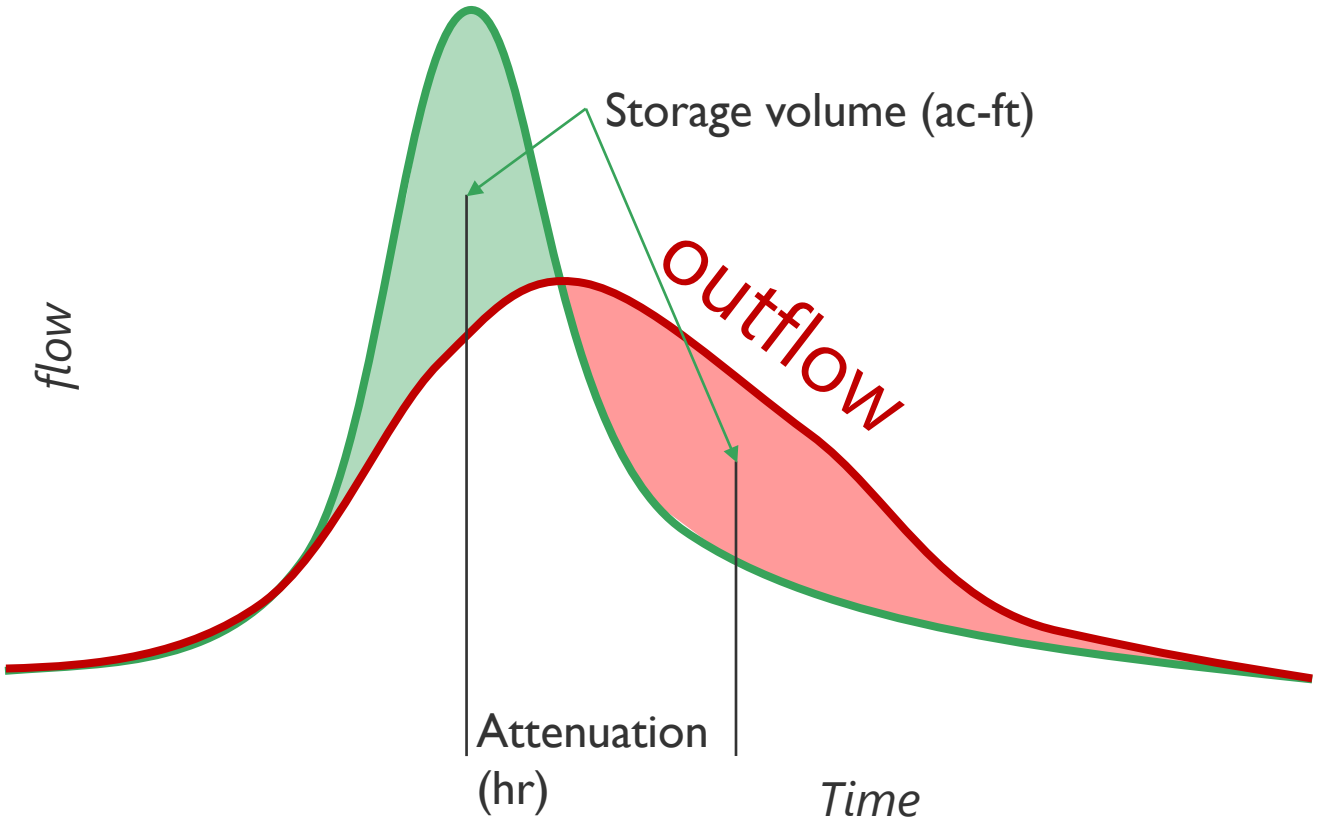


How it works: Storm Model

Typical +storage project performance example

Consider a new measure of flood-work, the ac-ft-hr

Example 1 ac-ft, moved 1 hour off-peak = 1 ac-ft-hr



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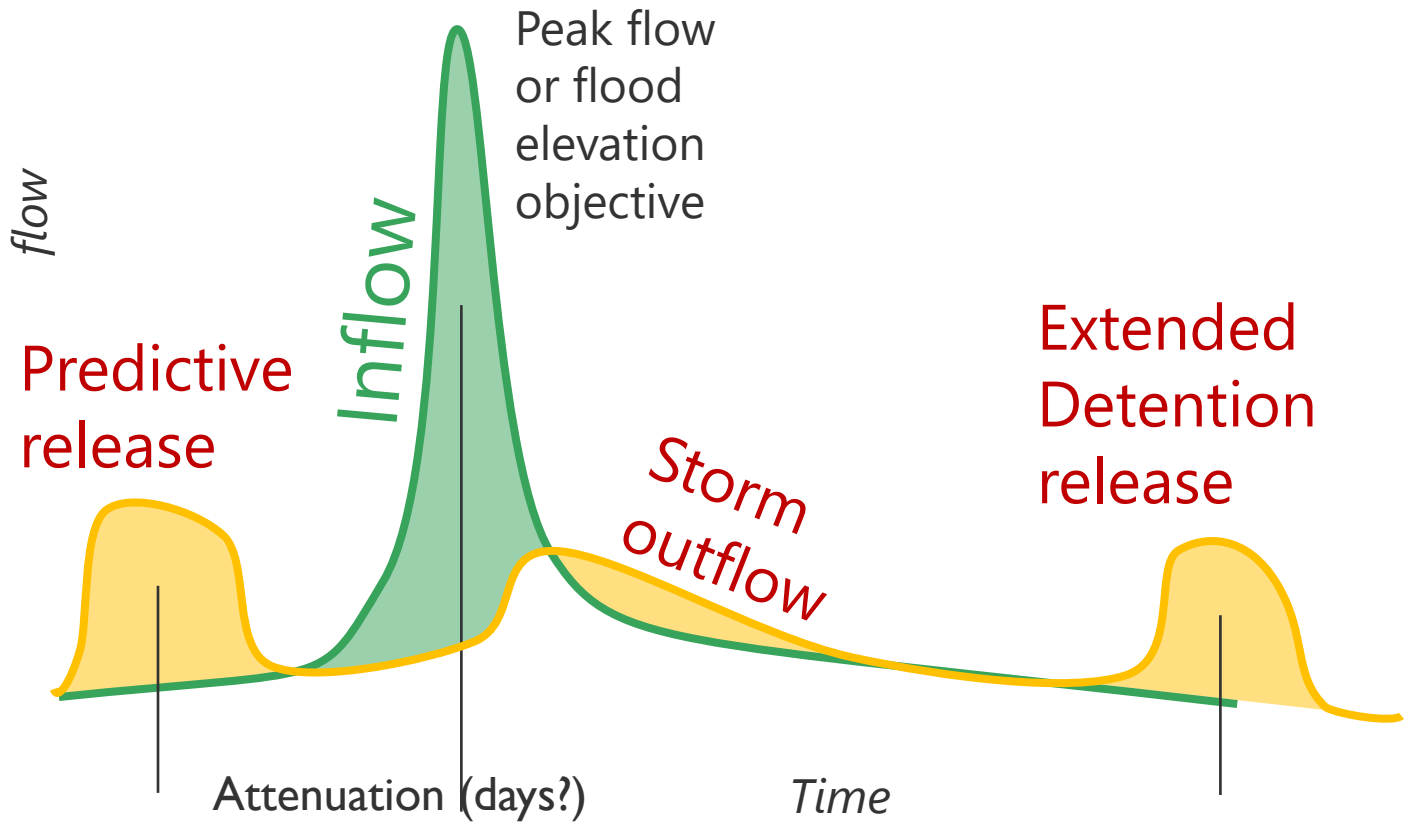
How it works: Storm Model

Smart storage project performance example

Can move flow ahead of storm…

…or long after a storm



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How it works: Storage

868.3 1% probability elevation (+58.5ac-ft)

864 10% probability elevation (+12.3ac-ft)

860-862.4 (16.8ac-ft Extended detention volume)

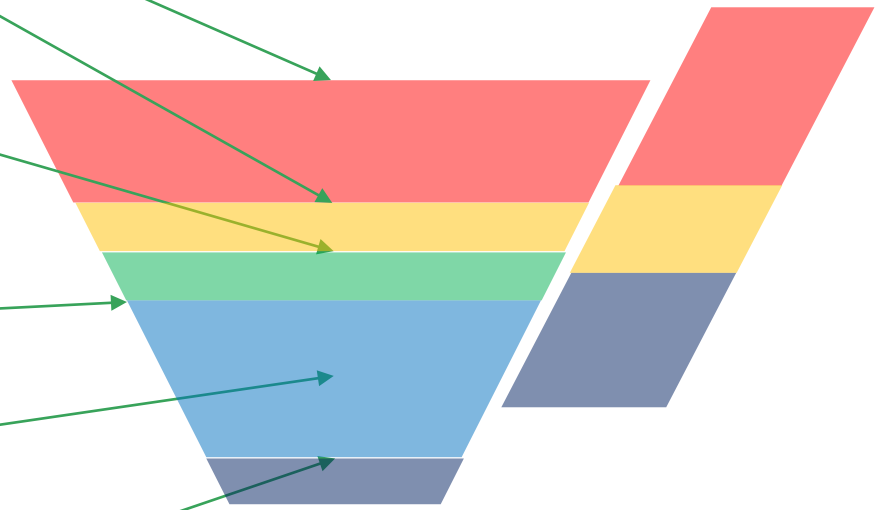
- Hold 3 days before allowing pump down draw down as needed for future storms

860 fuzzy normal

856-860 (23.2ac-ft Drawdown volume)

- Use 2' first for storms and clean water
- Use next 2' for extreme storms

855-856 (5ac-ft below effective pump)



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Storage Value

Earthwork (43560 cf/ac-ft / 27cf/cy x $25/cy)

= $40 K/ac-ft

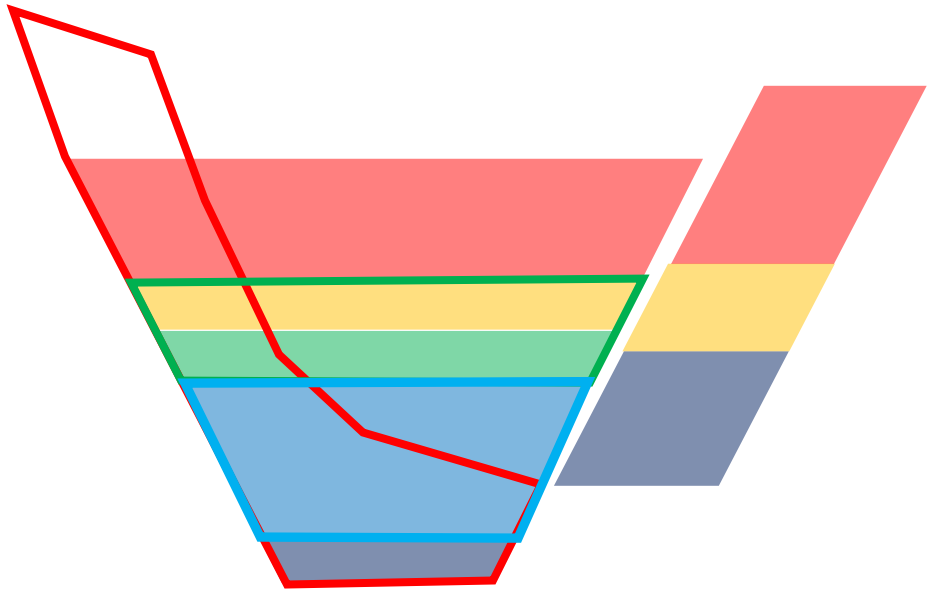
Modify outlet hydraulics ($500K/40 ac-ft)

= $12.5 K/ac-ft

Add smart outlet ($125K/40 ac-ft)

= $3.1 K/ac-ft

We found a diminishing cost per marginal unit of flood storage for our project



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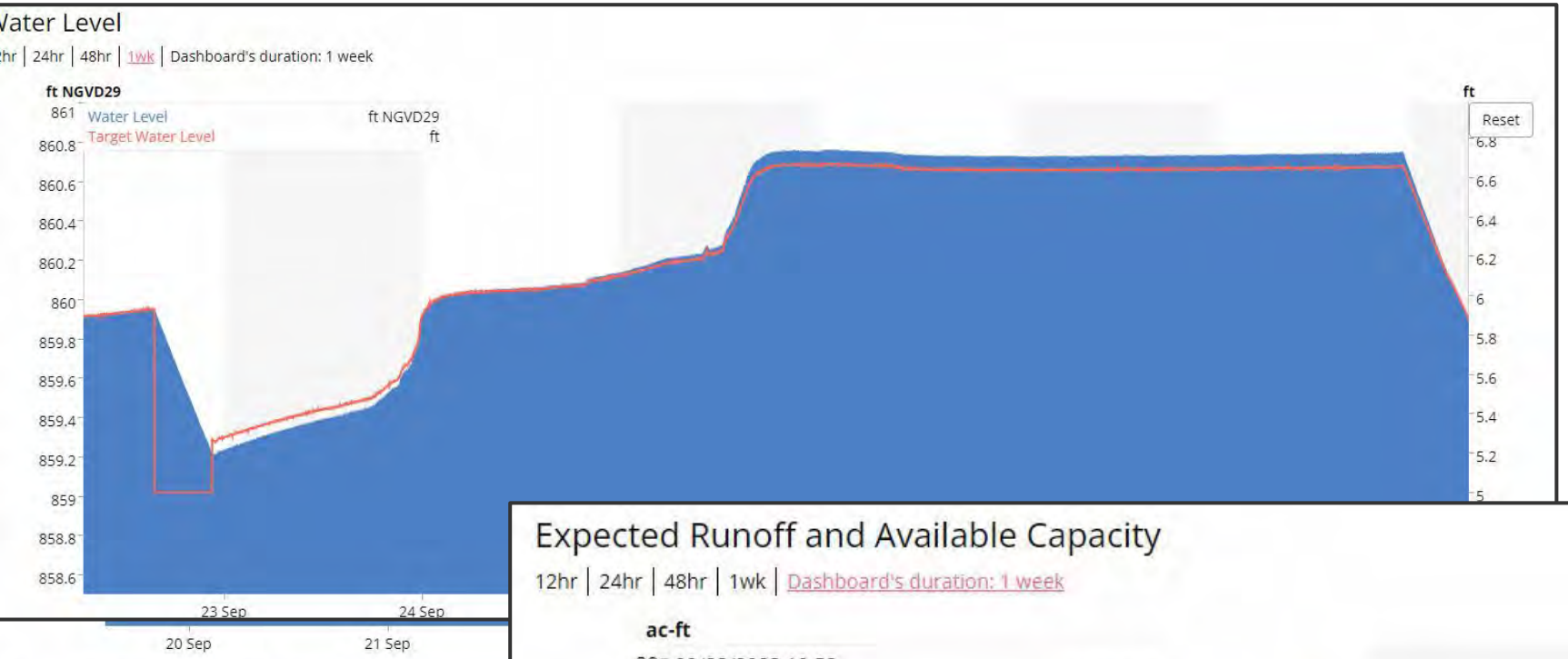
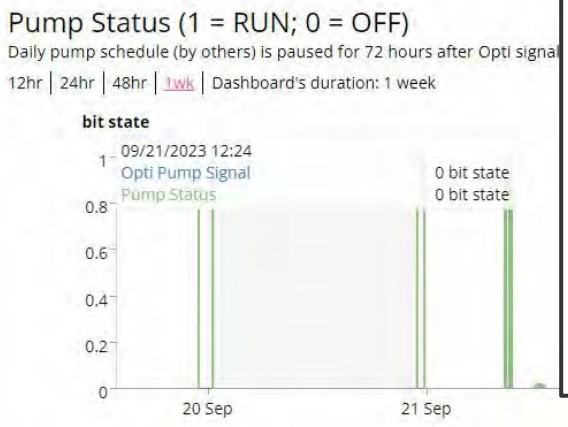
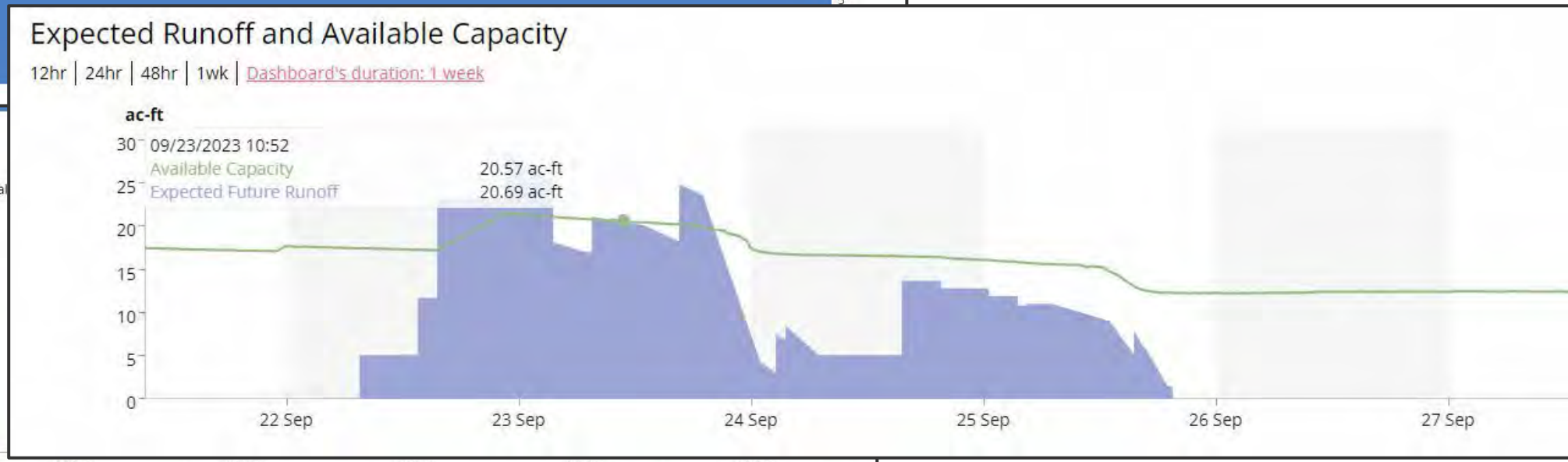
How it works: Example UI







- Water level
- Pump status
- Expected runoff & available capacity
- +forecast data

How it works: Algorithm

Clean water behavior

- Maximize settling duration

Rules Based

- 3+ day hold, overridden by next storm drain-downs

Storm behavior

- Minimize flow at peak of event

- Partial drain-down
- not allowed during rainfall

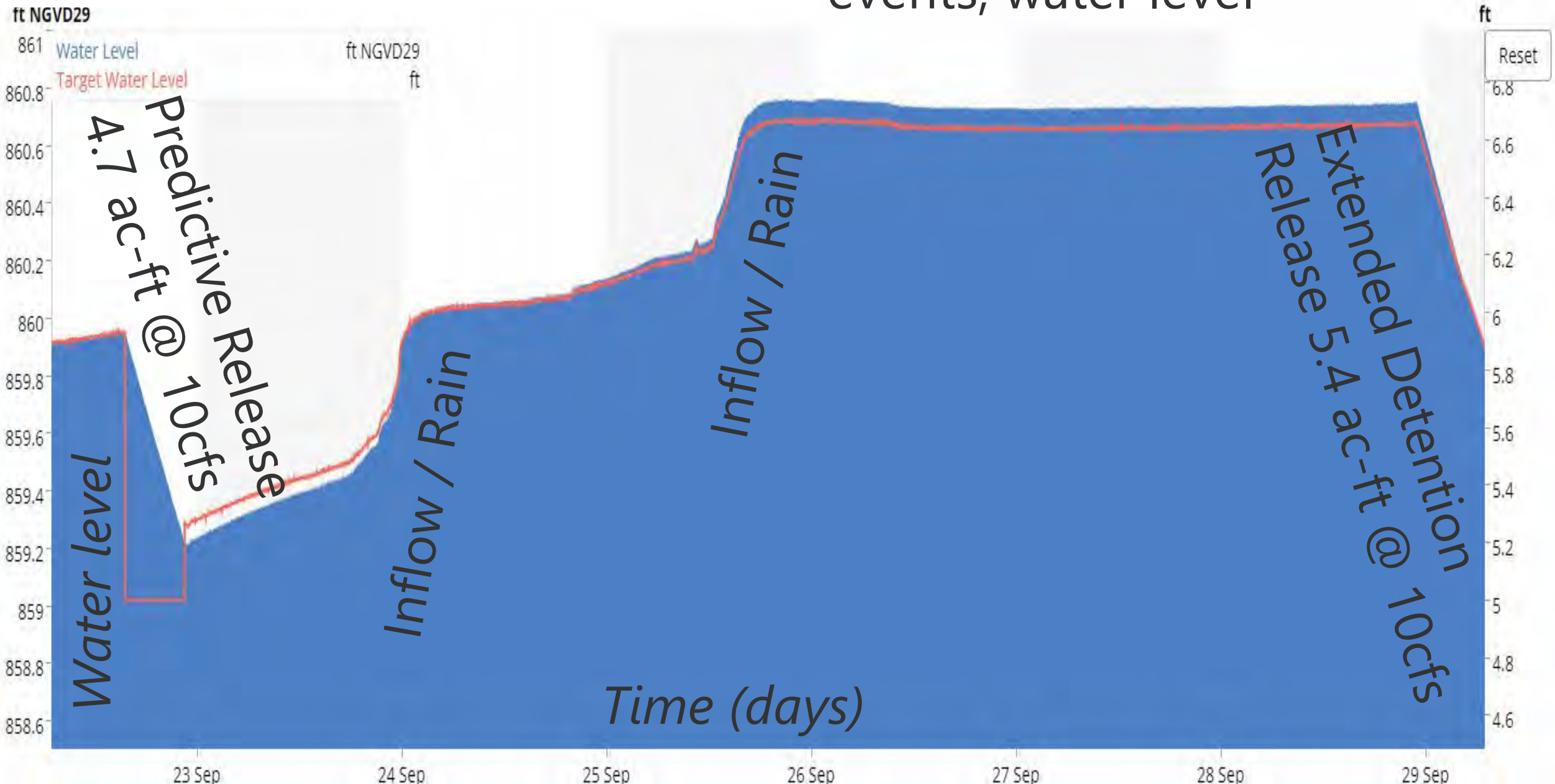
Extreme storm behavior

- Minimize peak elevation and flow at peak of event

- Full drain-down
- Allowed during rain ahead of peak for extreme rainfall

How it works: Example

10/23-29 2023, zero outflow events, water level



Value: Flood / clean water services

- 100% reduction in wet weather discharge in 95%+ of storms from controlled area (1.3" runoff, ~2.5-3.25" event)
- More effective use of storage for both flood and clean water services
- Less erosive flood flows in downstream natural systems

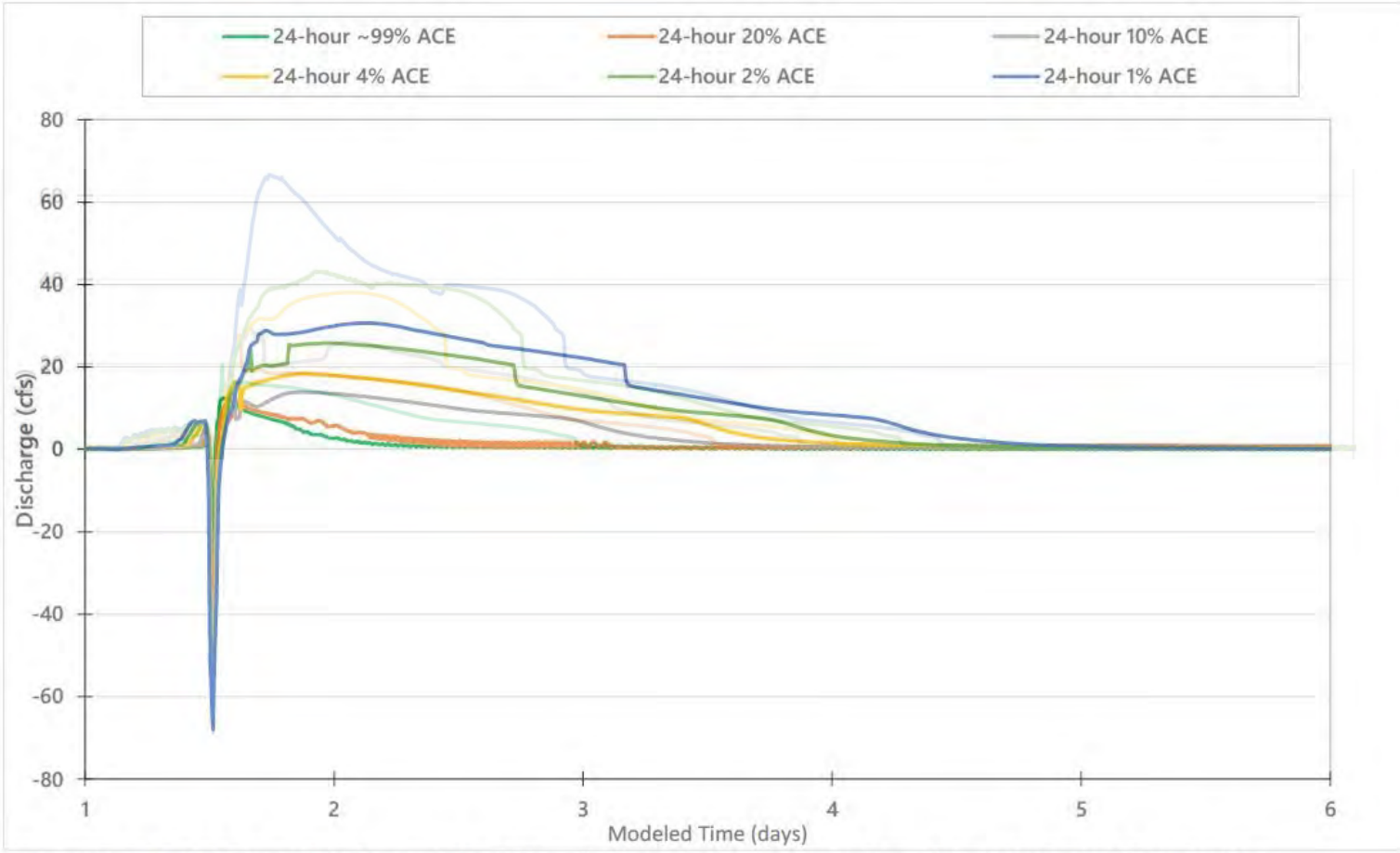
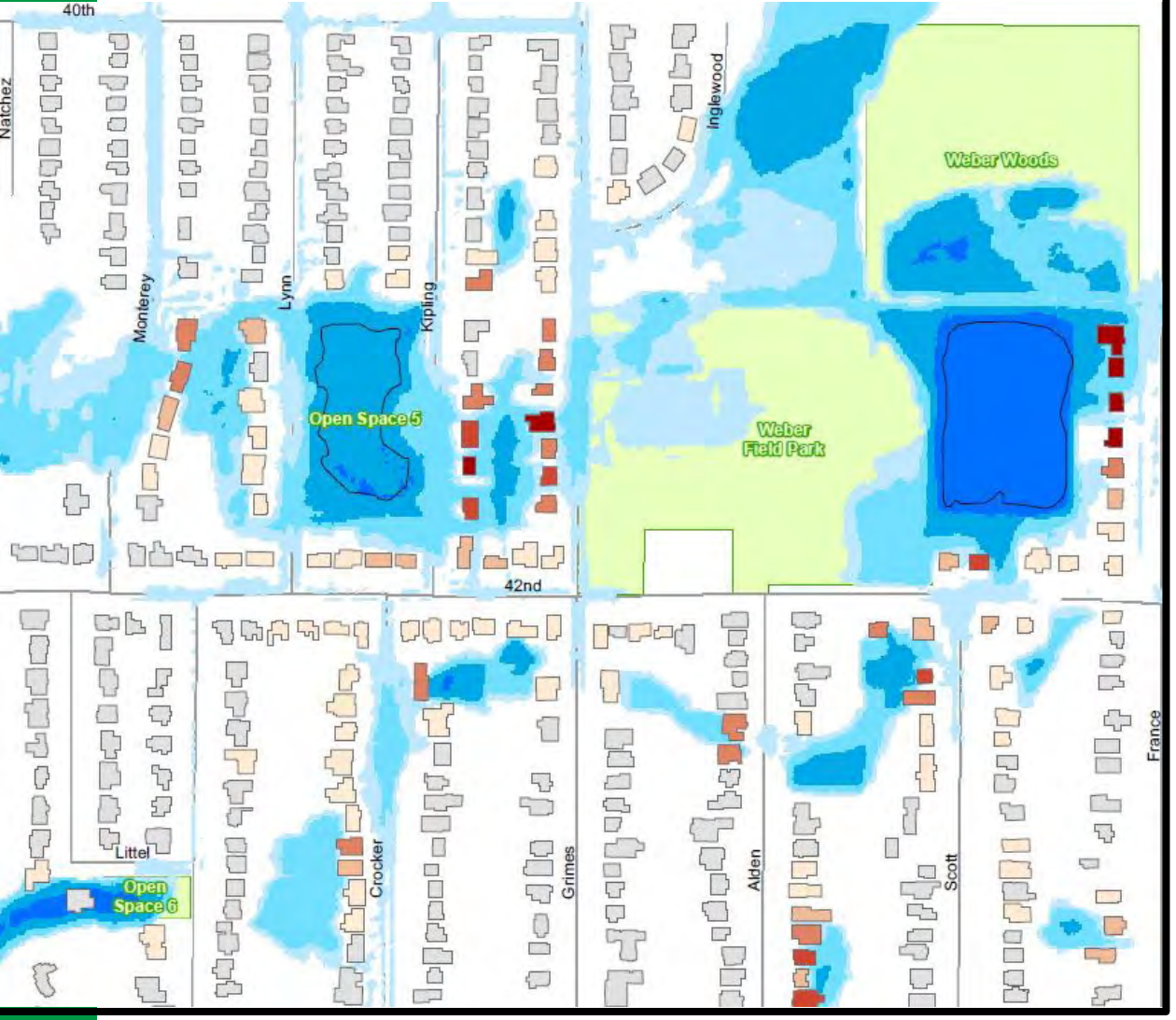
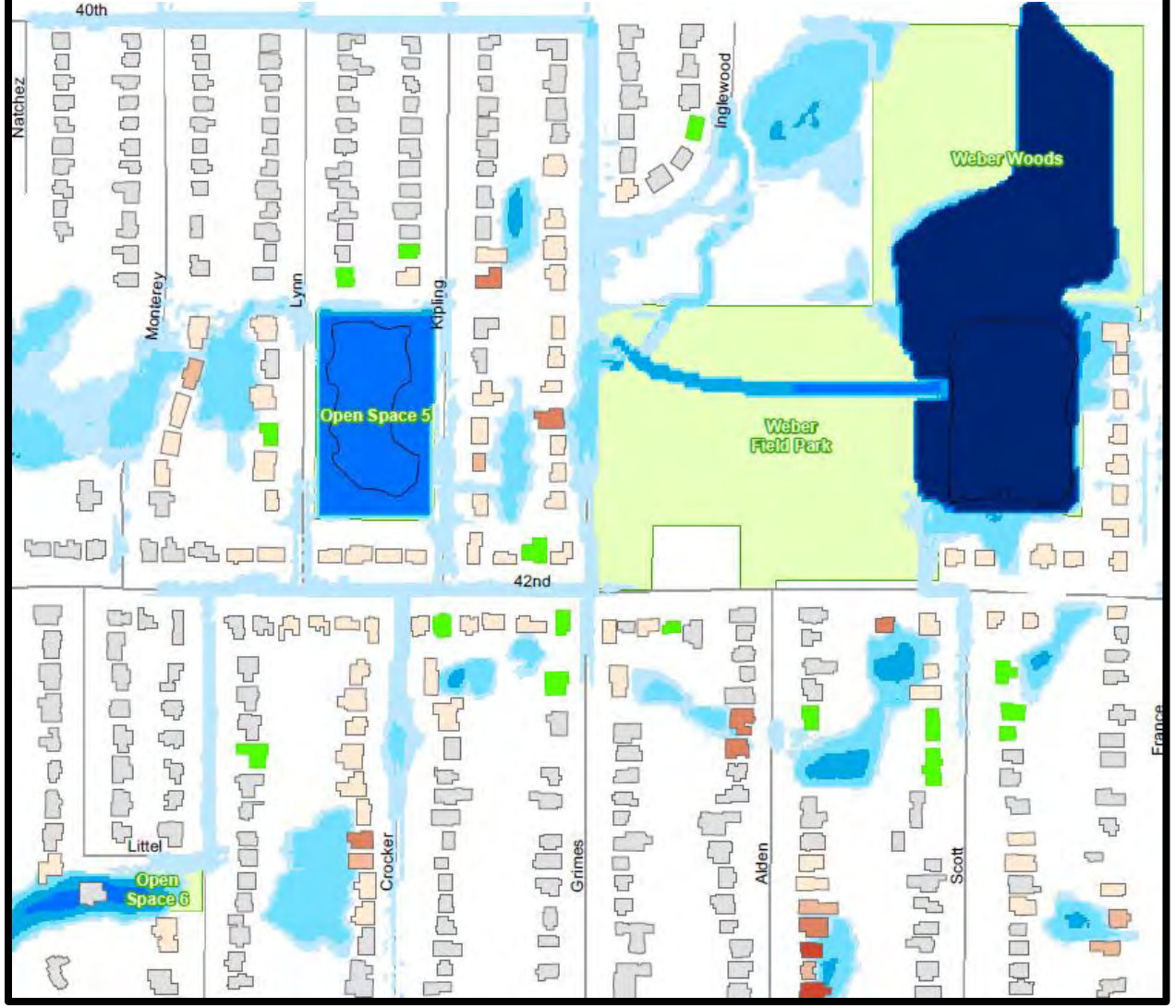


Figure 3-5 Total Flow hydrograph of the 24-hour storms crossing the city boundary in the proposed condition





- ~ 30 structures risk removed, 130+ risk reduced,
- ~ 60 acre-feet of new flood storage (pond expansion 37, predictive pumping 23)
- $13M spent for MFIP ($250K Flood Damage Reduction Grant)

Next Steps

Partnership study at watershed scale

- Nine Mile Creek WD, City of Edina, Bloomington, Richfield, Eden Prairie, Minnetonka, MN-DNR
- Multi-objective (flood, clean water, ecosystem health, streamflow dynamics)
- Multi-locations (key points of flood constraint, key water quality targets)
- Governance and regulatory hurdles
- 2025+ retrofit
- 20 year $50M plan for flood risk reduction

Contact

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City of Edina

rbintner@edinamn.gov

952-903-5713

The CITY of EDINA

Public Works Department

Administration, Engineering, Maintenance, Utilities

Bloomington 1987 Super Storm and Urban Flooding

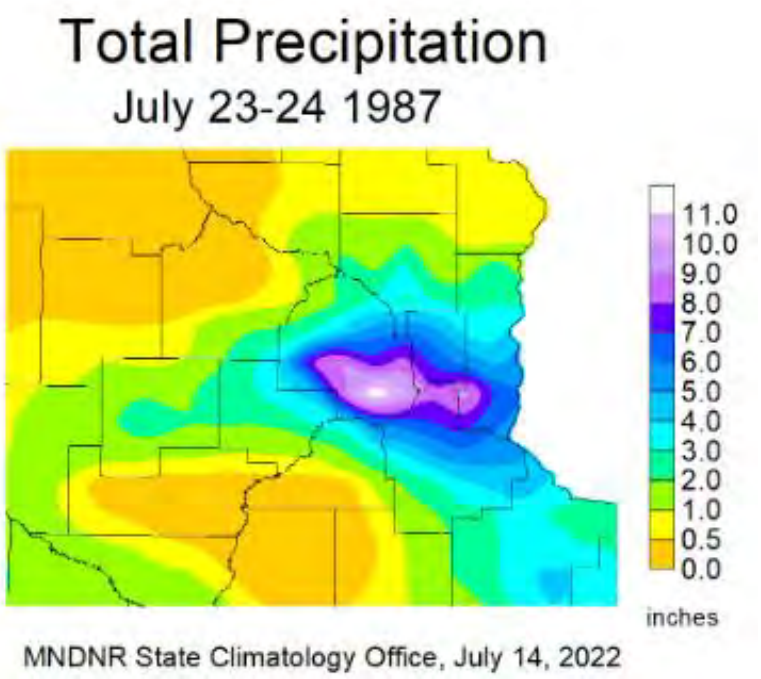
Bryan Gruidl, City of Bloomington

July 17, 2024

Twin Cities Superstorm of July 1987

East Bush Lake Road

Twin Cities Superstorm of July 1987



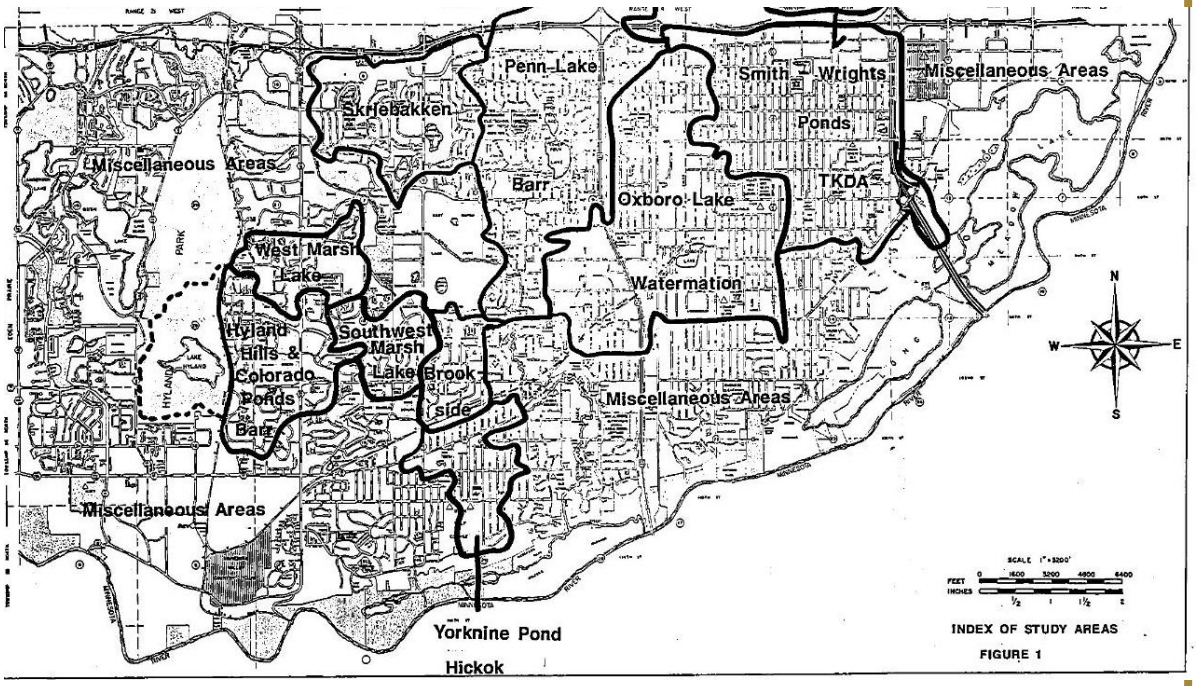
- 7/20/1987 – Bloomington received between 4 and 7 inches of rain in 6 hours.
- 7/23-24/1987 6-10 inches of additional rain fell in about 5 hours.
  - A highly localized and nearly stationary severe thunderstorm complex
- Five-day totals were 14-16 inches in Bloomington.

Damage

- Infrastructure – roads, storm sewer & culverts
- Overland flow resulting in:
  - Failed retaining walls
  - Slope failures
  - Erosion
- Residential homes and Businesses
  - Wet basements
  - Basements filled with flood water to main level
  - Collapsed basement walls

Response

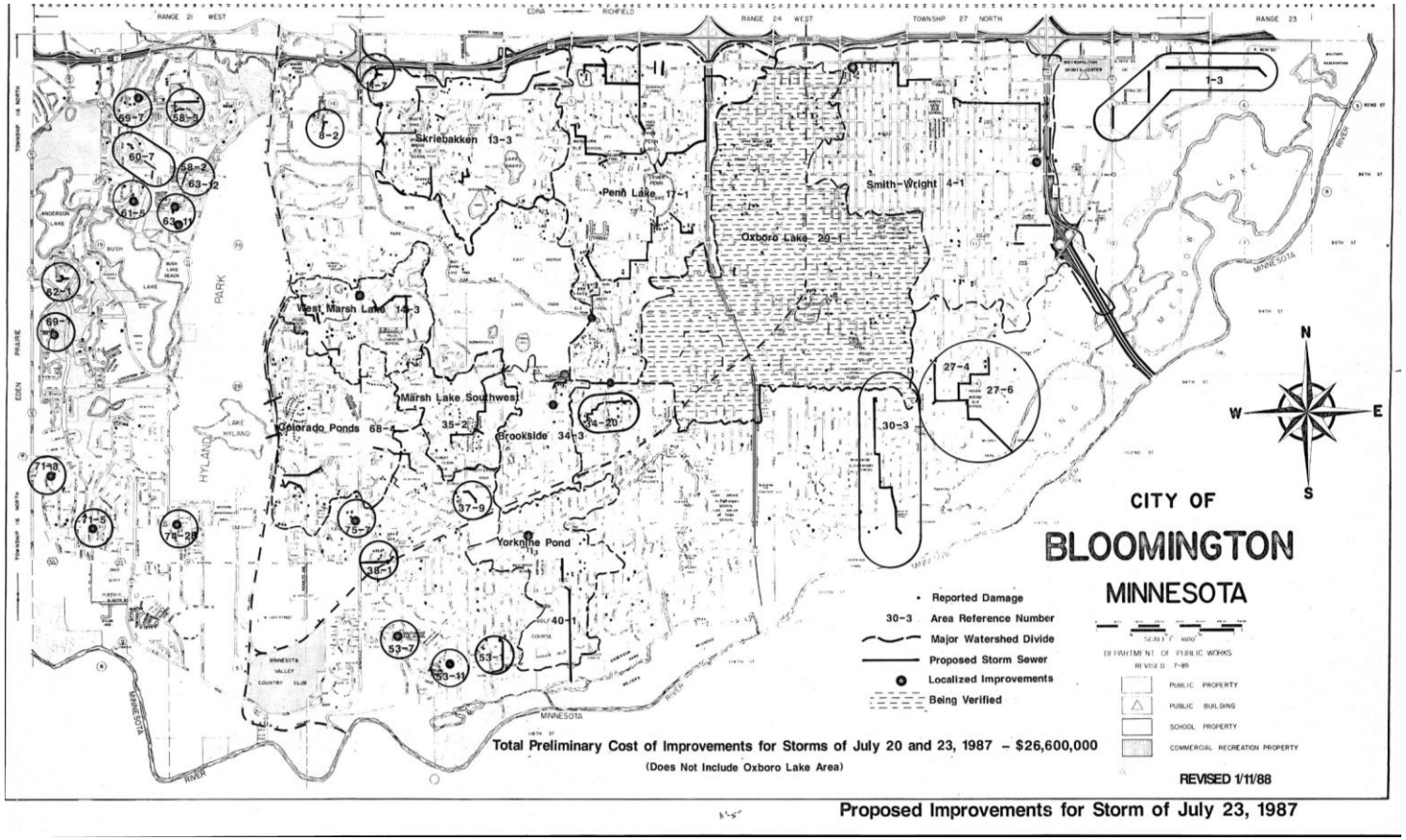
- City divided into multiple different study areas
- Evaluated 3 different design criteria:
  - 1% chance event
  - 1% chance event with safety factor
  - July 23 storm event w/ antecedent moisture conditions



Estimated Cost based on initial analysis

	100-yr Storm	100-yr Storm w/ Safety Factor	July 23, 1987 Storm
Total Estimated Cost	$14,620,000	$18,820,000	$42,640,000

Preliminary Improvements map

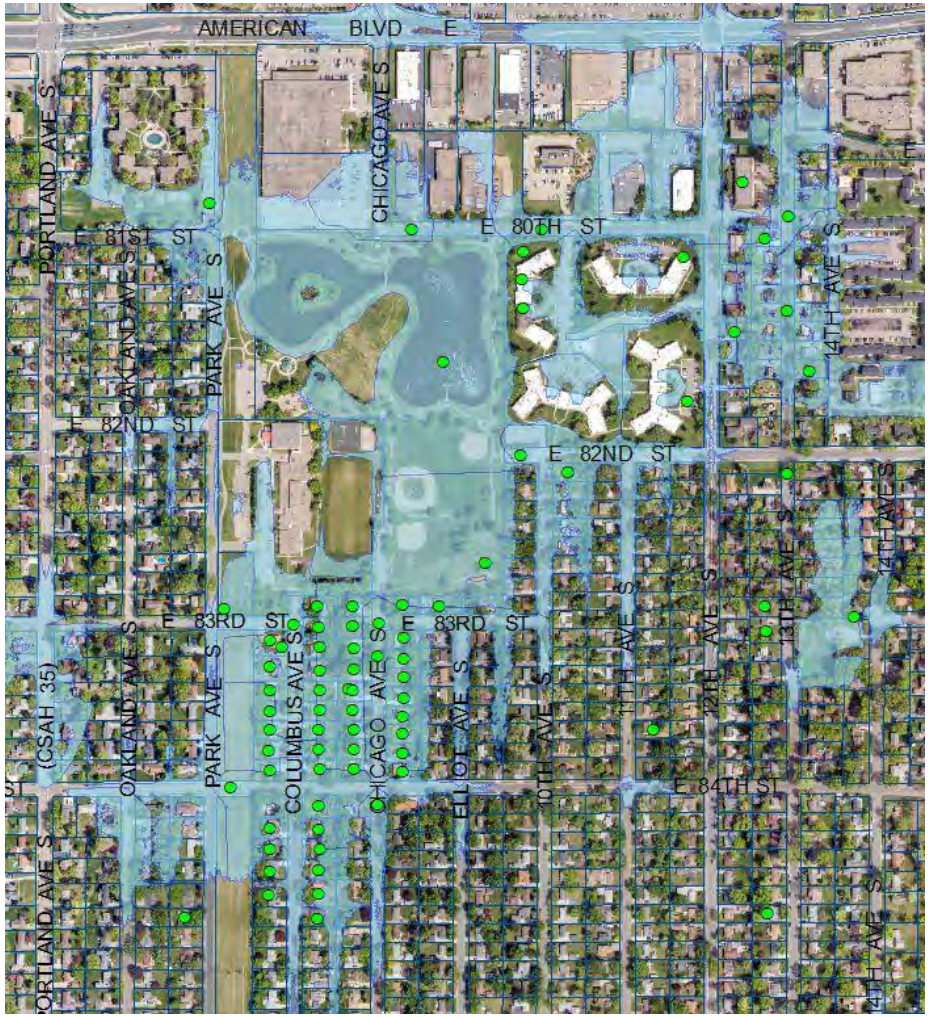


Financing

- Establishment of Bloomington's Stormwater utility fee
  - **SEC. 11.42. ESTABLISHMENT OF STORMWATER DRAINAGE UTILITY.**
    - Pursuant to Minnesota Statutes, Section 444.075, the City establishes a storm water drainage utility and authorizes the imposition of just and reasonable charges for the use and availability of storm sewer facilities.
    - *(Added by Ord. No. 88-41, 5-23-88)*
- Volume and water quality component
- Five distinct land uses
  - Cemeteries, Parks, Golf Courses
  - Single-family and duplex residential
  - Public and Private Schools and Institutions
  - Multi-family Residential and Churches
  - Commercial and Industrial

Where are we now?

- Modeled storm sewer system
- Inundation mapping (1% chance event shown)
- Working with community to understand risk
- Still working on implementing projects to reduce flood risk



Questions?